SB4253E02
Jan. 2008

# Power Train

## Specification
## System Operation
## Testing & Adjusting

**D20S-5, D25S-5, D30S-5, D33S-5, D35C-5**
**G20E-5, G25E-5, G30E-5**
**GC20E-5, GC25E-5, GC30E-5, GC33E-5**
**G20P-5, G25P-5, G30P-5, G33P-5, G35C-5**
**GC20P-5, GC25P-5, GC30P-5, GC33P-5**

# Important Safety Information

Most accidents involving product operation, maintenance and repair are caused by failure to observe basic safety rules or precautions. An accident can often be avoided by recognizing potentially hazardous situations before an accident occurs. A person must be alert to potential hazards. This person should also have the necessary training, skills and tools to perform these functions properly.

**Read and understand all safety precautions and warnings before operating or performing lubrication, maintenance and repair on this product.**

Basic safety precautions are listed in the “Safety” section of the Service or Technical Manual. Additional safety precautions are listed in the “Safety” section of the owner/operation/maintenance publication.
Specific safety warnings for all these publications are provided in the description of operations where hazards exist. WARNING labels have also been put on the product to provide instructions and to identify specific hazards. If these hazard warnings are not heeded, bodily injury or death could occur to you or other persons. Warnings in this publication and on the product labels are identified by the following symbol.

**⚠ WARNING**

**Improper operation, lubrication, maintenance or repair of this product can be dangerous and could result in injury or death.**
**Do not operate or perform any lubrication, maintenance or repair on this product, until you have read and understood the operation, lubrication, maintenance and repair information.**

Operations that may cause product damage are identified by NOTICE labels on the product and in this publication.

DOOSAN cannot anticipate every possible circumstance that might involve a potential hazard. The warnings in this publication and on the product are therefore not all inclusive. If a tool, procedure, work method or operating technique not specifically recommended by DOOSAN is used, you must satisfy yourself that it is safe for you and others. You should also ensure that the product will not be damaged or made unsafe by the operation, lubrication, maintenance or repair procedures you choose.

The information, specifications, and illustrations in this publication are on the basis of information available at the time it was written. The specifications, torques, pressures, measurements, adjustments, illustrations, and other items can change at any time. These changes can affect the service given to the product. Obtain the complete and most current information before starting any job. DOOSAN dealers have the most current information available.

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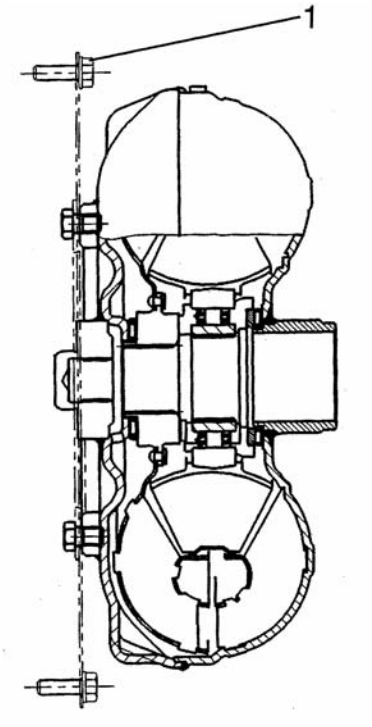
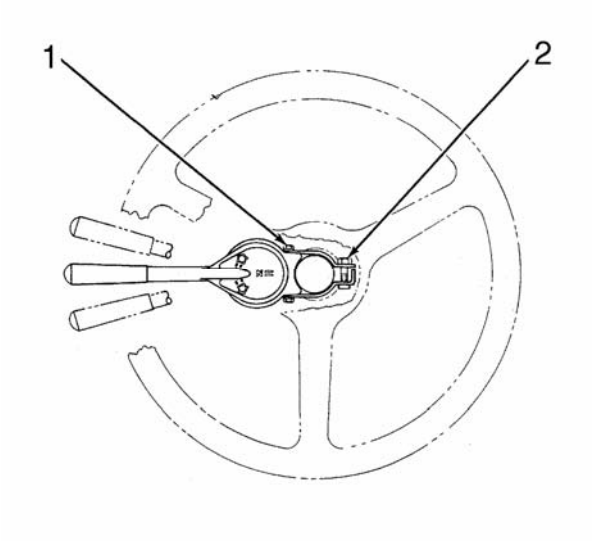
# Specification

## Torque Converter




(1) Torque for six bolts that hold torque converter drive plate to the flywheel ..... 45 ± 7 N·m (33 ±5 lb·ft)

## Forward and Reverse Control Group




(1) Torque for screws (four) that hold clamp to hand control switch……..3.4 to 3.9 N·m (30 to 35 lb·in)

(2) Torque for bolts (two) that hold clamp to steering column……2.8 to 3.4 N·m (25 to 30 lb·in)

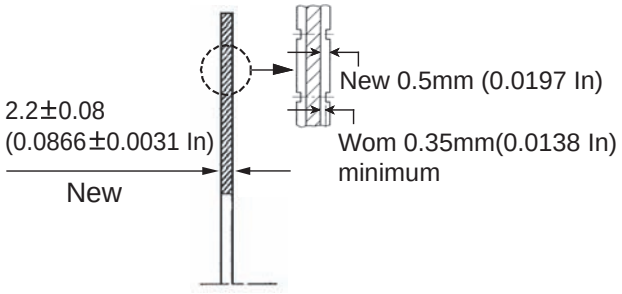
Apply a bead of LOCTITE NO.242 Sealant to inner radius of the clamp, prior to assembly.

## Transmission Solenoid

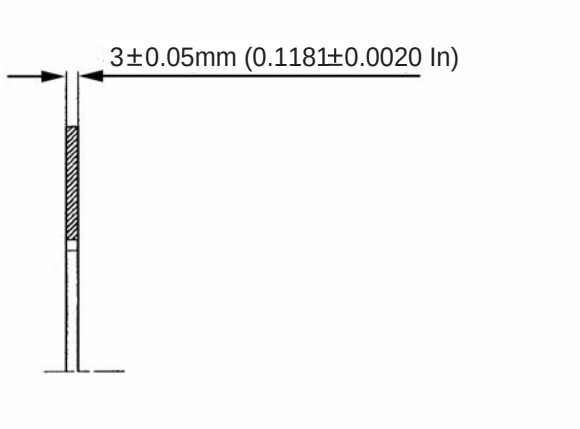
Valve block elements located on top of transmission housing……9.7 to 10.3 ohms

For additional solenoid and valve group specifications see section “Valve block elements”

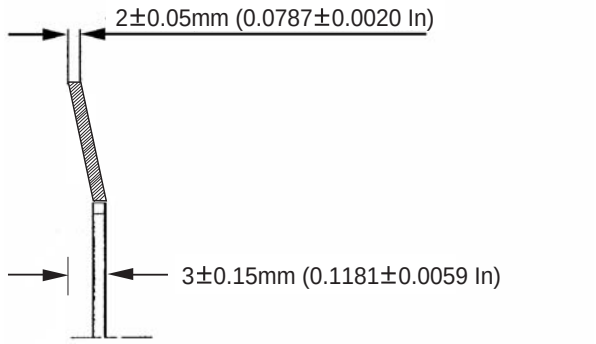
# Forward / Reverse Clutch Elements



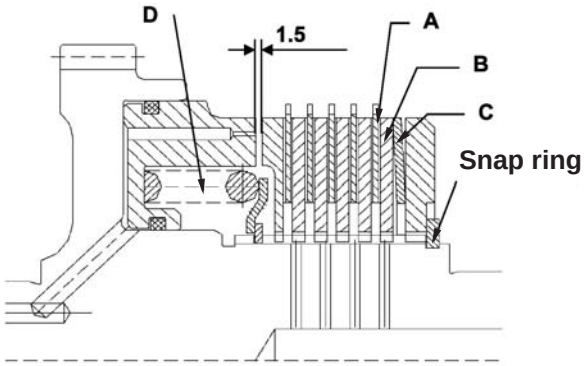

a) Outer clutch Disc




b) Inner clutch Plate



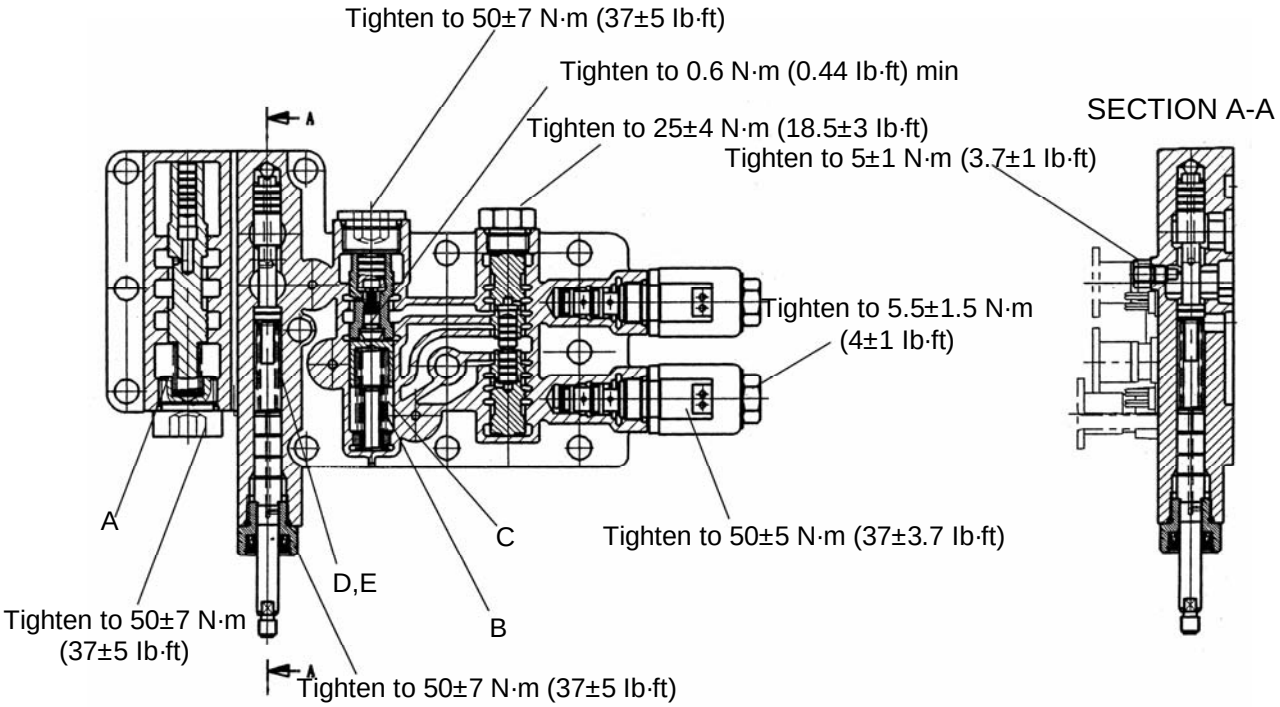

c) Bend plate
Inside diameter..... 60mm (2.36 in)
Outside diameter..... 122.5mm (4.82 in)




d) Piston return spring
Length under test force ..... 23.1 mm (0.91 in)
Test force .....969.9 ±5 N (218.0 ± 11 lb)
Free length after test (nominal)..... 51 mm (2.0 in)
Outside diameter..... 95.5 mm (3.74 in)

e) Clearance between piston and pressure disc
..... 1.5 mm (0.059 in)

# Valve Block Elements


Tighten to 50±7 N·m (37±5 lb·ft)
Tighten to 0.6 N·m (0.44 lb·ft) min
Tighten to 25±4 N·m (18.5±3 lb·ft)
Tighten to 5±1 N·m (3.7±1 lb·ft)
SECTION A-A
Tighten to 5.5±1.5 N·m (4±1 lb·ft)
A
C
Tighten to 50±5 N·m (37±3.7 lb·ft)
D,E
B
Tighten to 50±7 N·m (37±5 lb·ft)
Tighten to 50±7 N·m (37±5 lb·ft)

A) Spring
- Length under test force……..22.5 mm (0.89 in)
- Test force ..... 42 ± 3.4 N (9.4±0.8 lb)
- Free length after test(nominal)...34.65 mm (1.36 in)
- Outside diameter……...13 mm (0.51 in)

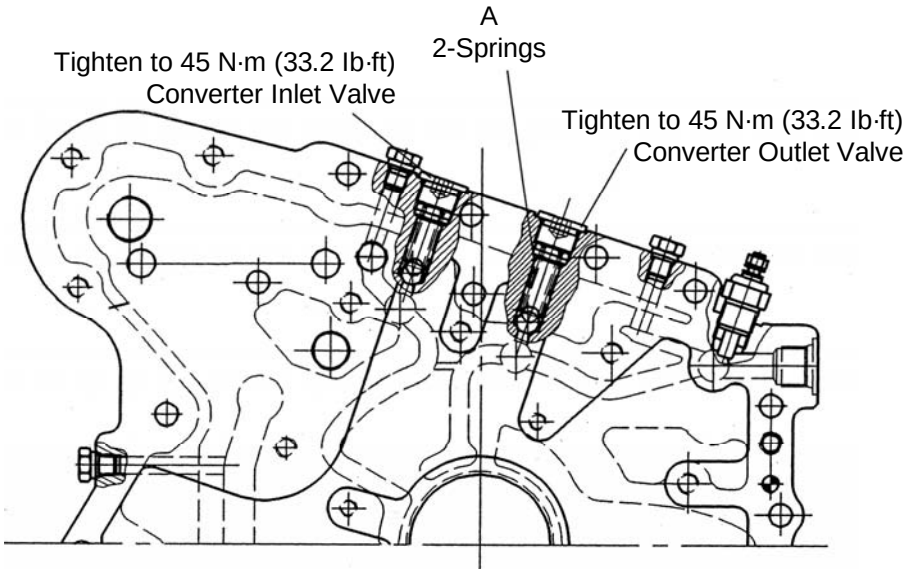
B) Spring (Inner)
- Length under test force…….26.6 mm (1.05 in)
- Test force……37.8 ± 3.0 N (8.5±0.7 lb)
- Free length after test (nominal)….48.2 mm (1.90 in)
- Outside diameter…….10.8 mm (0.43 in)

C) Spring (outer)
- Length under test force……...26.6 mm (1.05 in)
- Test force……..75.6 ± 6.0N (17.0±1.3 lb)
- Free length after test (nominal)… 49.2 mm (1.94 in)
- Outside diameter…… .15.24 mm (0.60 in)

D) Spring (outer)
- Length under test force……22.22 mm (0.87 in)
- Test force……...29 to 34 N (6.5 to 7.6 lb)
- Free length after test (nominal)….31.7 mm (1.25 in)
- Outside diameter……...11.91 mm (0.47 in)

E) Spring (Inner)
- Length under test force……..…20.0 mm (0.79 in)
- Test force……...3.34 ± 0.27 N (0.75±0.06 lb)
- Free length after test (nominal)...55.93 mm (2.20 in)
- Outside diameter……..7.75 mm (0.305 in)

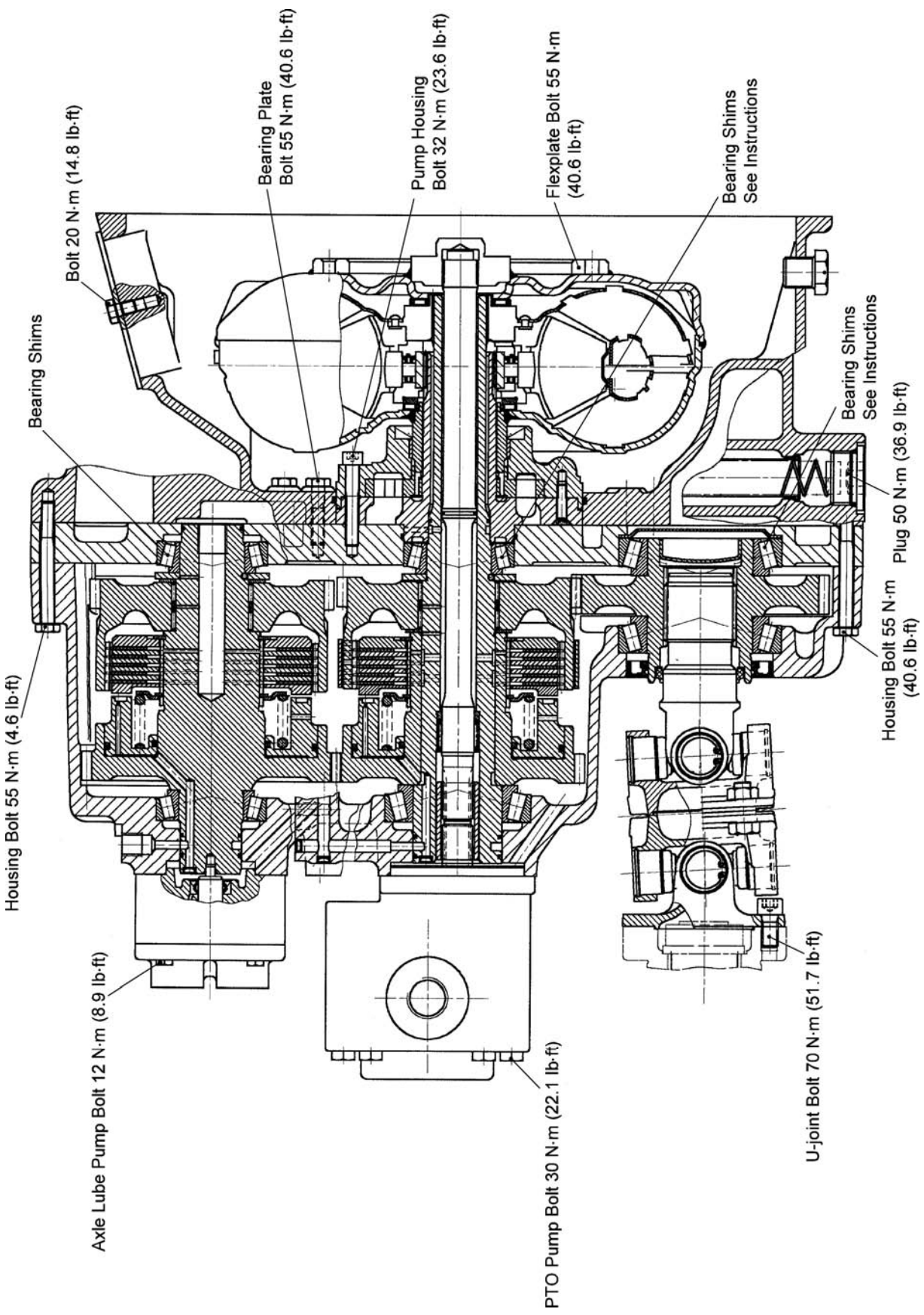
# Valve Spring in Transmission Bearing Plate



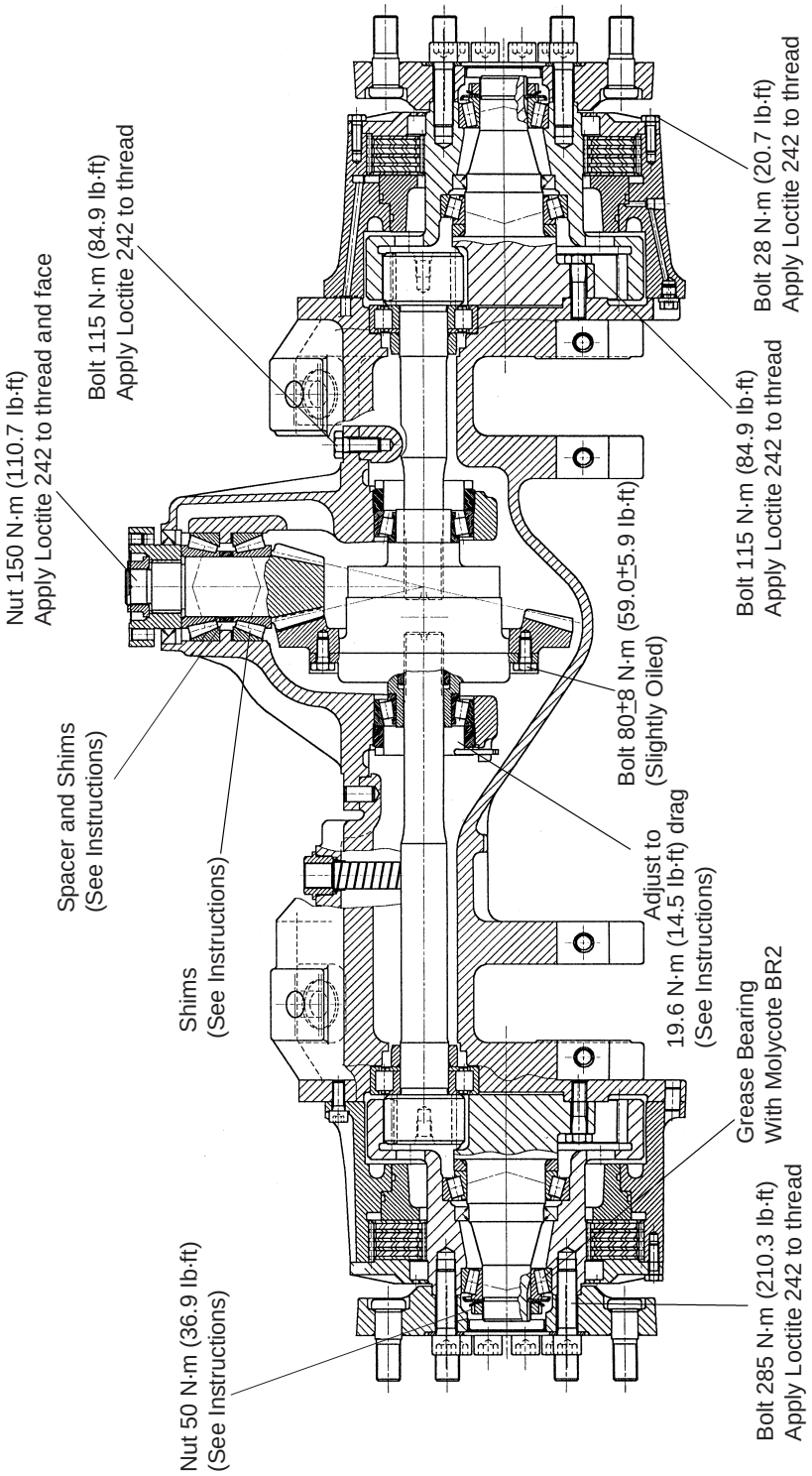

A) Spring
Length under test force…….30 mm (1.18 in)
Test force……..18.1 ± 1.8 N (4.07±0.4lb)
Free length after test(nominal)...43.25 mm (1.70 in)
Outside diameter……10.7 mm (0.42 in)

# Tightening Torques

## Transmission

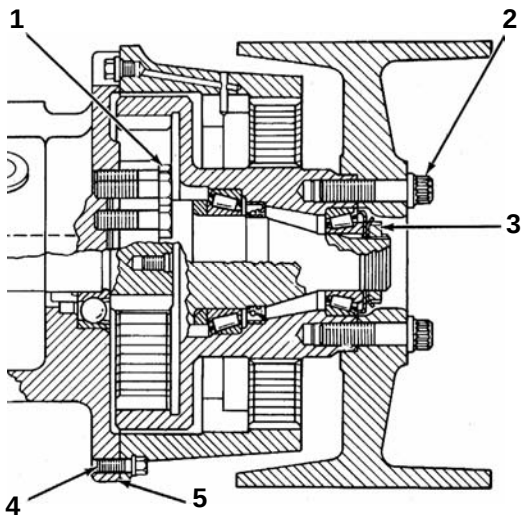


## Drive axle


Nut 150 N·m (110.7 lb·ft)
Apply Loctite 242 to thread and face
Bolt 115 N·m (84.9 lb·ft)
Apply Loctite 242 to thread
Bolt 28 N·m (20.7 lb·ft)
Apply Loctite 242 to thread
Bolt 115 N·m (84.9 lb·ft)
Apply Loctite 242 to thread
Bolt 80+8 N·m (59.0+5.9 lb·ft)
(Slightly Oiled)
Spacer and Shims
(See Instructions)
Shims
(See Instructions)
Adjust to
19.6 N·m (14.5 lb·ft) drag
(See Instructions)
Grease Bearing
With Molycote BR2
Nut 50 N·m (36.9 lb·ft)
(See Instructions)
Bolt 285 N·m (210.3 lb·ft)
Apply Loctite 242 to thread

# Final Drives and Wheels

## GC Model Trucks




Oil Cooled Disc Brake Type

(1) Apply LOCTITE NO.242 Thread Lock to threads of spindle bolts.
Torque for bolts that hold spindle to drive axle housing……..115 ± 14 N·m (85 ± 10 lb·ft)

(2) Torque for wheel mounting bolts ....270 ± 25 N·m .....(200 ± 20 lb·ft)

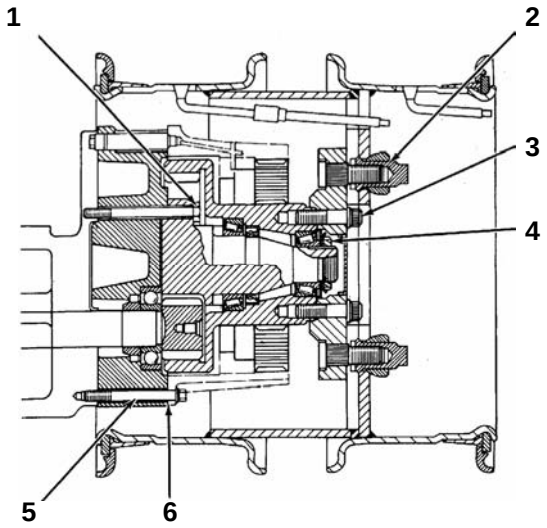
(3) Wheel bearing adjustment :

(a) Tighten wheel bearing nut to 135 N·m (100lb·ft) while the wheel is turned in both directions.
(b) Loosen the nut completely. Tighten the nut again to 50 ± 5 N·m (37 ± 4 lb·ft).
(c) Bend a tab of the lockwasher into a groove of the wheel bearing nut.

(4) Torque for bolts that hold cover to axle housing ……..55 ± 10 N·m (40 ± 7 lb·ft)

(5) Apply Loctite No.515 Sealant to the axle flange and cover on the contact area.

## D, G Model Trucks
## Dual Drive wheels




Oil Cooled Disc Brake Type

(1) Apply LOCTITE NO.242 Thread Lock to threads of spindle bolts.
Torque for bolts that hold spindle to drive axle housing .....115 ± 14 N·m (85 ± 10 lb·ft)

(2) Use a crisscross procedure to tighten nuts.

(a) Torque for single drive wheel mounting. nuts.....644 ± 34 N·m (470 ± 25 lb·ft)
(b) Torque for inner and outer dual drive wheel mounting nuts....644 ± 34 N·m (470 ± 25 lb·ft)

(3) Torque for bolts that hold adapter assembly to hub ..... 285 ± 13 N·m (210 ± 10 lb·ft)

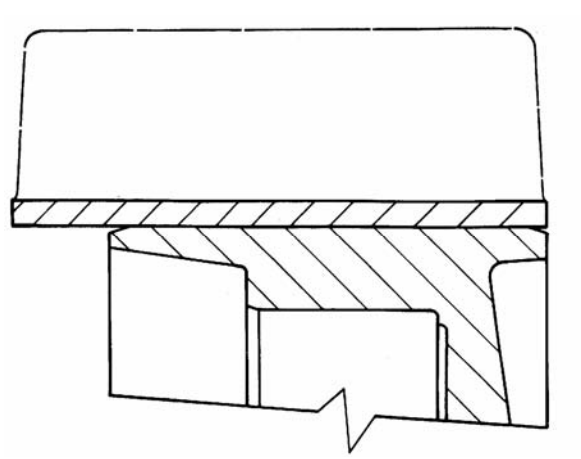
(4) Wheel bearing adjustment :

(a) Tighten wheel bearing nut to 135 N·m(100 lb·ft) while the wheel is turned in both directions
(b) Loosen the nut completely. Tighten the nut again to 50 ± 5 N·m (37 ± 4 lb·ft).
(c) Bend a tab of the lockwasher into a groove of the wheel bearing nut.

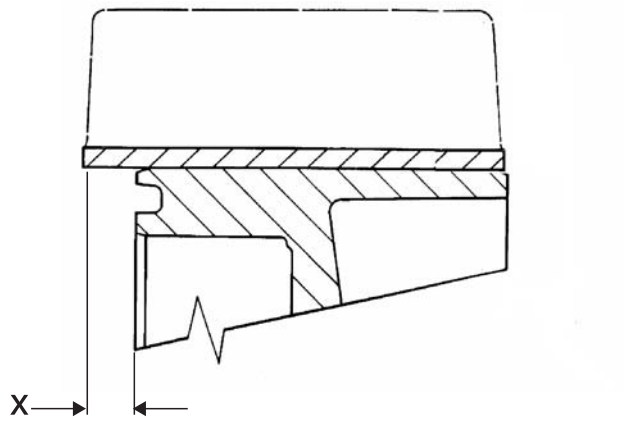
(5) Torque for bolts that hold cover to axle housing ..... .....55 ± 10 N·m (40 ± 7 lb·ft).

(6) Apply Loctite No.515 Sealant to the axle flange or spacer and cover on the contact area.

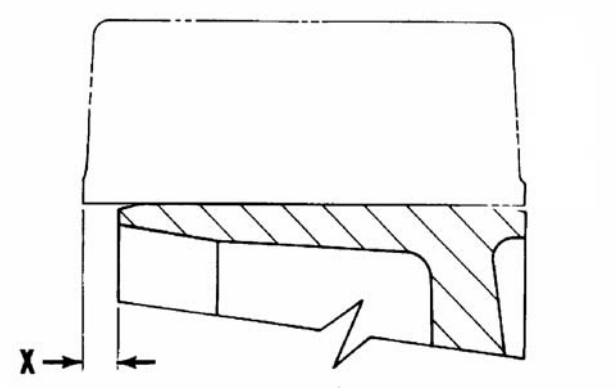
# Drive Tire Installation



GC20, GC25 Models




GC30, GC32 Models-Wide Axle




GC30, GC32 Models-Narrow Axle

**⚠ WARNING**

**The drive tire must be installed as shown below. Failure to do so will decrease the stability of the truck, and can cause injury to the operator.**

## GC20, GC25 Models

Install the tire so that the edge of the tire is even with the outside edge of the wheel.

## GC30, GC32 Models

**Narrow Axle :**

Install the tire so there is distance (X) between the edge of the tire and the inside edge of the wheel.

Distance(X) is……37 ± 1 mm (1.46 ± 0.04 in)

**Wide Axle :**

Install the tire so there is distance (x) between the edge of the tire and the outside edge of the wheel.

Distance(X) is.....37 ± 1 mm (1.46 ± 0.04 in)

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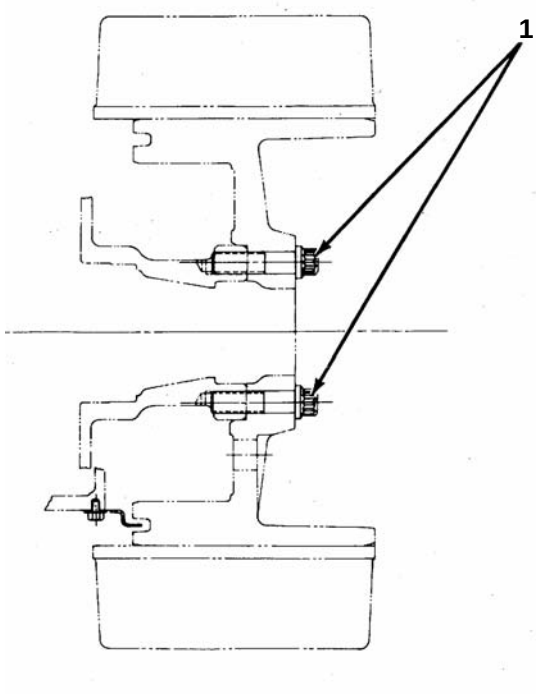
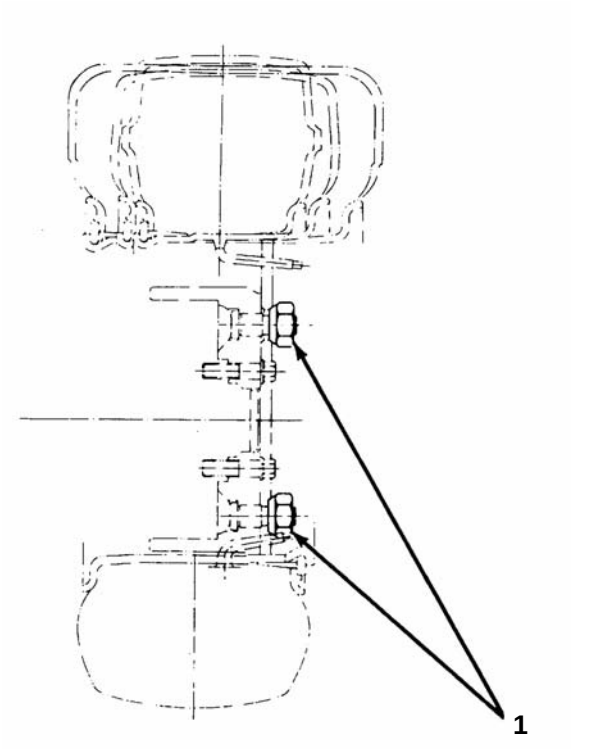
# Drive Wheel Installation

## GC Model Trucks



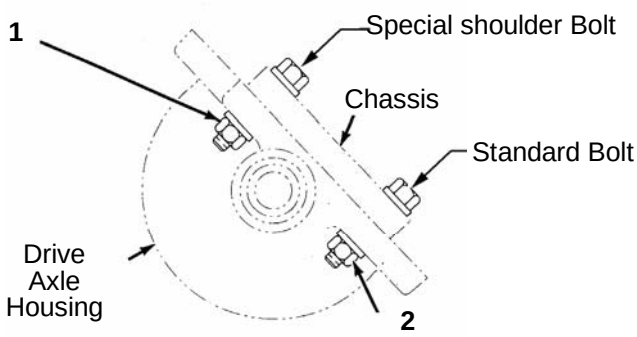

(1) Tighten wheel mounting bolts to a torque of ……270 ± 25 N·m (200 ± 20 lb·ft)

## D, G Model Trucks




(1) Tighten wheel mounting bolts to a torque of ……644 ± 34 N·m (470 ± 25 lb·ft)
Use a crisscross procedure to tighten nuts.

# Drive Axle Mounting Group

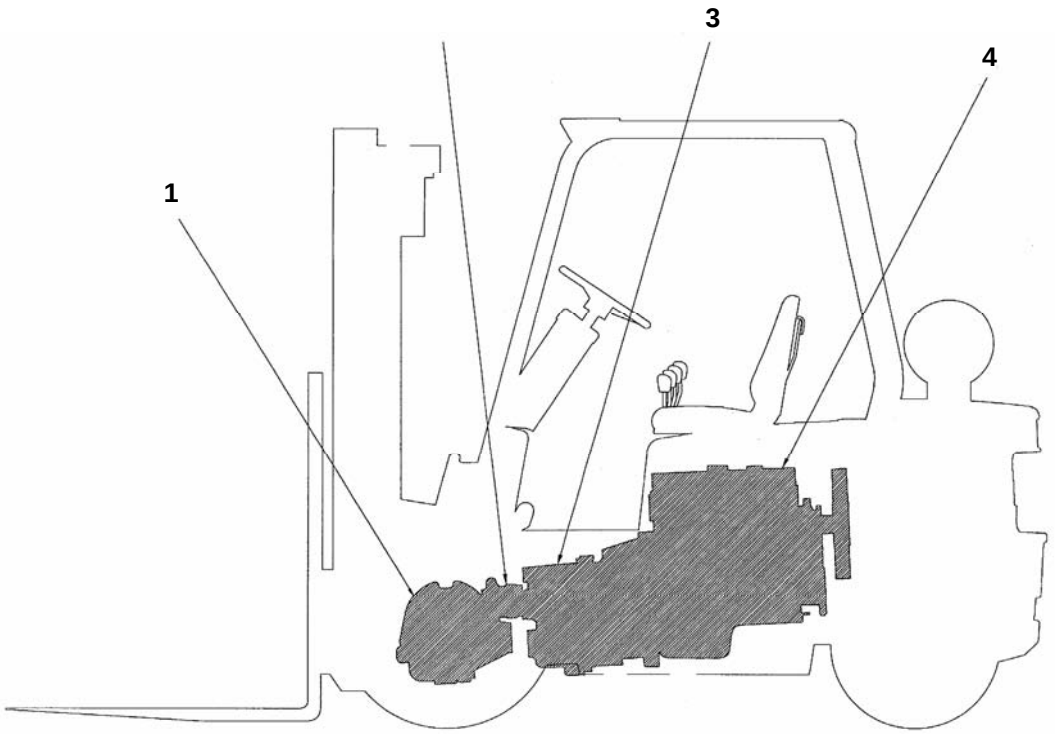



(1) Torque for two nuts that hold the axle to the chassis……..488 ± 27 N·m (360 ± 20 lb·ft)

(2) Torque for two nuts that hold the axle to the chassis.....……488 ± 27 N·m (360 ± 20 lb·ft)

# System Operation

## General Information




Power Flow
(1) Drive axle. (2) U-joint. (3) Transmission. (4) Engine.

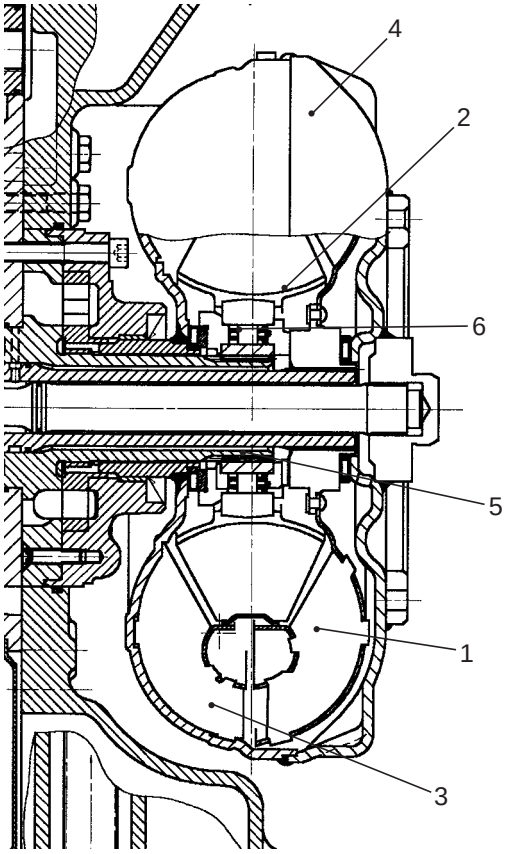
The basic components of the power train are engine (4), Transmission (3), U-Joint(2), Drive axle(1) and the final drives and wheels.

Two axle shafts connect the differential to two final drives. The drive wheels are mounted to the final drives.

Power from the engine goes through the flywheel into the torque converter. Power then flows through a transmission (3) and U-joint(2) to yoke of drive axle(1).
The transmission has two hydraulically operated clutch packs that are spring released.
The transmission has one speed in forward and one speed in reverse.

Power from yoke of drive axle is sent through a spiral bevel gear set to the differential.
The differential sends power out through the axles to the final drives and wheels.

## Torque Converter




Torque converter
(1) Turbine. (2) Stator. (3) Impeller. (4) Housing.
(5) Stator support. (6) Stator clutch.

There is no direct mechanical connection between engine and the transmission. Power from the engine is transferred through the torque converter, which hydraulically connects the engine to the transmission. Transmission drive train oil is used to turn the turbine and transmission input shaft.

When the lift truck works against a load, the torque converter can multiply the torque from the engine and send a higher torque to the transmission.

The torque converter has four main parts : housing (4), impeller(pump) (3), turbine(1) and stator(2). The housing is connected to the engine flywheel through a flexplate. Impeller (3) and housing (4) are welded together and turn with the engine flywheel at engine speed and in the direction of engine rotation. Turbine (1) turns the transmission input shaft. Stator (2) is installed stationary on stator support (5) by a freewheel clutch that allows one way rotation of the stator.

The hub, which is part of impeller (3), fits into the transission oil pump. The turning impeller (3) rotates the pump to supply oil for the operation of the torque converter and transmission

When the engine is turning, oil flows through the converter to lubricate and cool it. With the transmission in neutral, the impeller, turbine, stator and oil are all turning together in a direct fluid coupling. The turbine/impeller speed ratio is 1/1.

Once a direction is selected the direct fluid coupling no longer exists, the turbine/impeller speed ratio changes (the turbine will be turning slower than the impeller). When this happens the impeller outlet pressure to turbine inlet pressure changes. This causes the oil flow in the torus (fluid path containing the impeller, turbine and stator) to gain momentum.

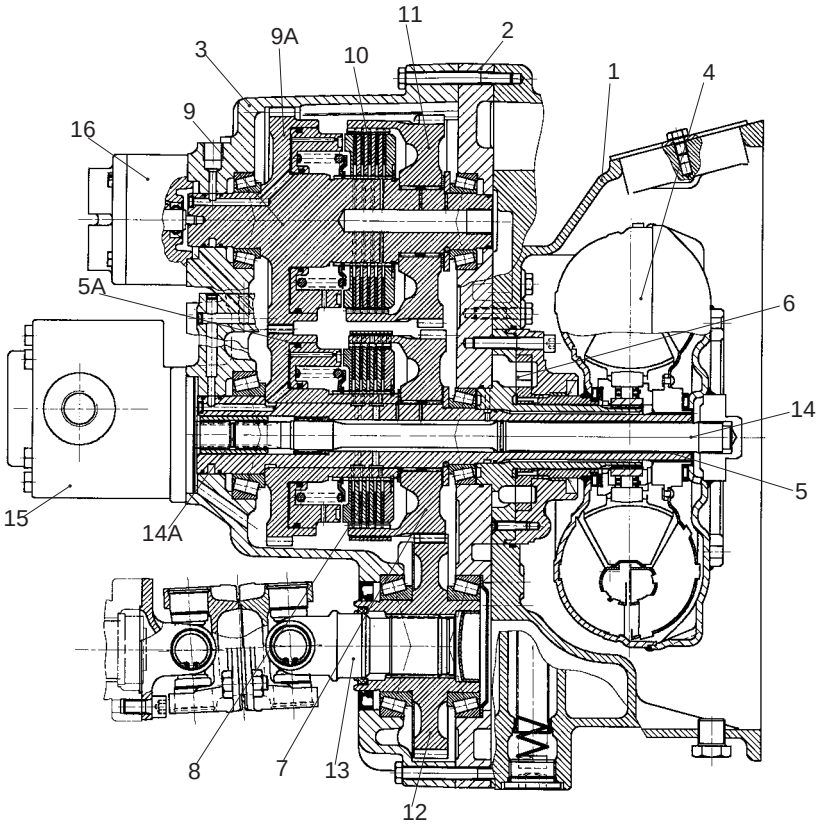
As impeller (3) turns, it increases the energy state of the oil and directs the oil to the outside diameter of converter housing (4). Oil leaving impeller (3) is directed to turbine (1) where much of the oil? energy is absorbed by turning the turbine. The pressure and flow change in the torus becomes torque and speed at the turbine and transmission input shaft.

Oil follows the turbine blades inward toward the center of the converter. When the turbine/impeller speed ratio is less than .85/1, oil is directed against the concave side of stator (2) with enough force to stop its one way rotation and lock the freewheel clutch.

Most of the energy from the oil that strikes the turbine is used to turn the turbine, but some energy is left over. Torque multiplication comes about because the locked stator (2) directs this left over oil back to impeller (3) in the same direction as the impeller rotation. This energy force of the oil increases the torque on the turbine and transmission input shaft. During operation, this cycle is repeated over and over.

Without the stator, oil leaving the turbine is travelling in a direction that is against impeller rotation. Torque multiplication is only possible because of the stator.

## Transmission




(1) TC Housing. (2) TM Bearing Plate. (3) TM Housing. (4) Torque Converter. (5) Input Shaft. (5A)Input Shaft Gear. (6) Oil Pump. (7) Forward Gear. (8) Forward Clutch. (9) Reverse Shaft. (9A) Reverse Shaft Gear. (10) Reverse Clutch. (11) Reverse gear. (12) Output gear. (13) U-joint. (14) Quill Shaft. (14A) Coupling. (15) PTO Pump. (16) Axle Lubrication Pump.

**The Transmission consists of 3 sections**:

a) TC housing (1) which contains torque converter (4) and the oil pump (6) and its housing. Tangs on the TC neck engage in and drive the pump.

b) Bearing plate (2) which contains the rear bearings of input, reverse shaft and output gear and the oil supply channels. The oil channels are sealed by the front TC housing wall.

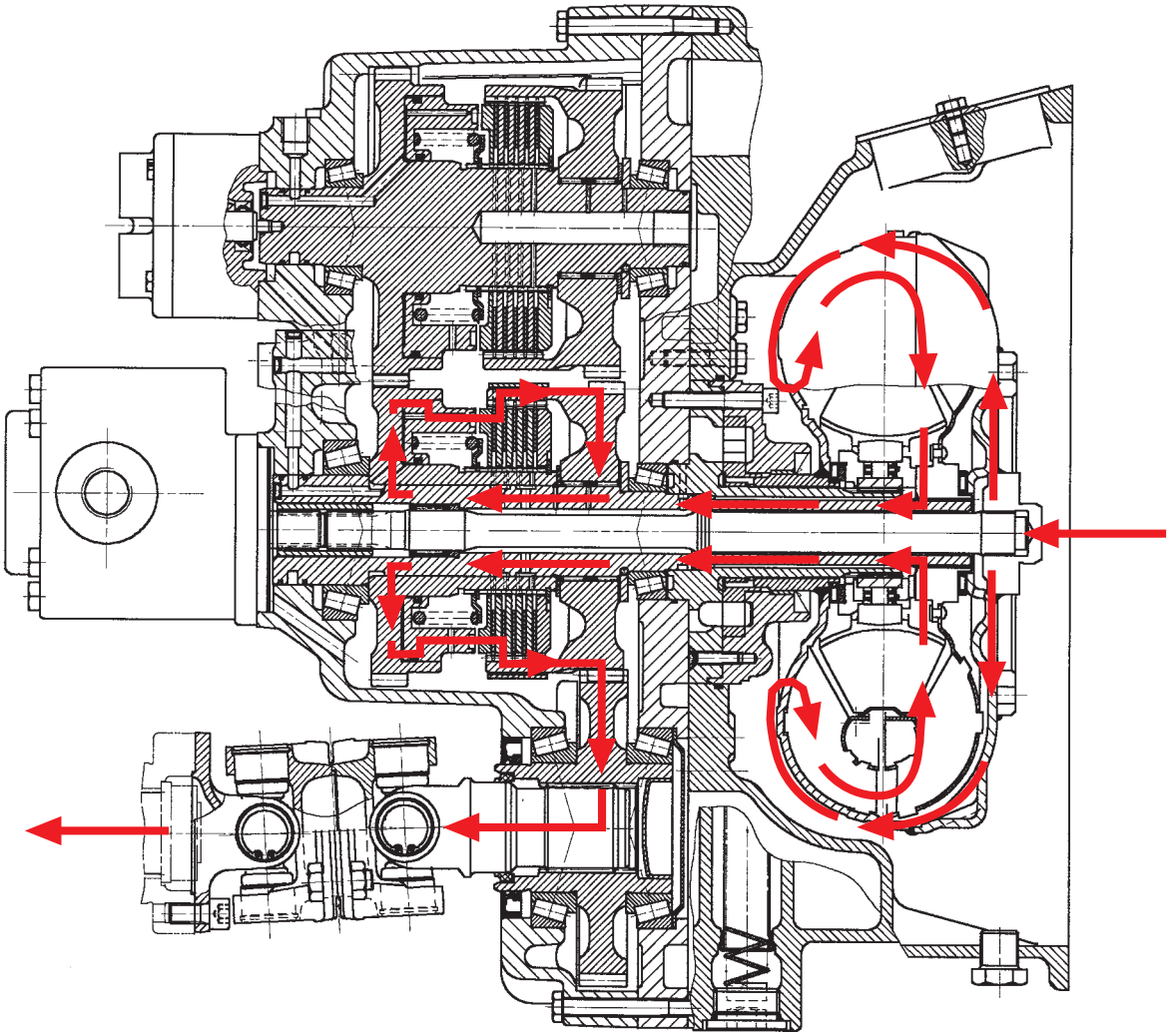
c) Transmission housing (3) containing input shaft (5), forward clutch (8), forward gear (7), reverse shaft (9), reverse clutch (10), reverse gear (11), output gear (12) and parking brake. The input shaft engages in and is driven by the TC turbine hub spline and rotates in same direction as the engine. It carries an input shaft gear (5A) which is in mesh and drives the reverse shaft gear (9A), the forward clutch (8) and the forward gear (7), which is in mesh and drives the output gear, when the forward clutch (8) is closed.

The reverse shaft (9) carries the reverse shaft gear (9A), the reverse clutch (10) and the reverse gear (11) which is in mesh and drives the output gear (12) when the reverse clutch (10) is selected.

The quill shaft (14) is splined to the torque converter and therefore rotates with engine speed and direction. A coupling (14A) connects the PTO pump (15) to the quill shaft (14).

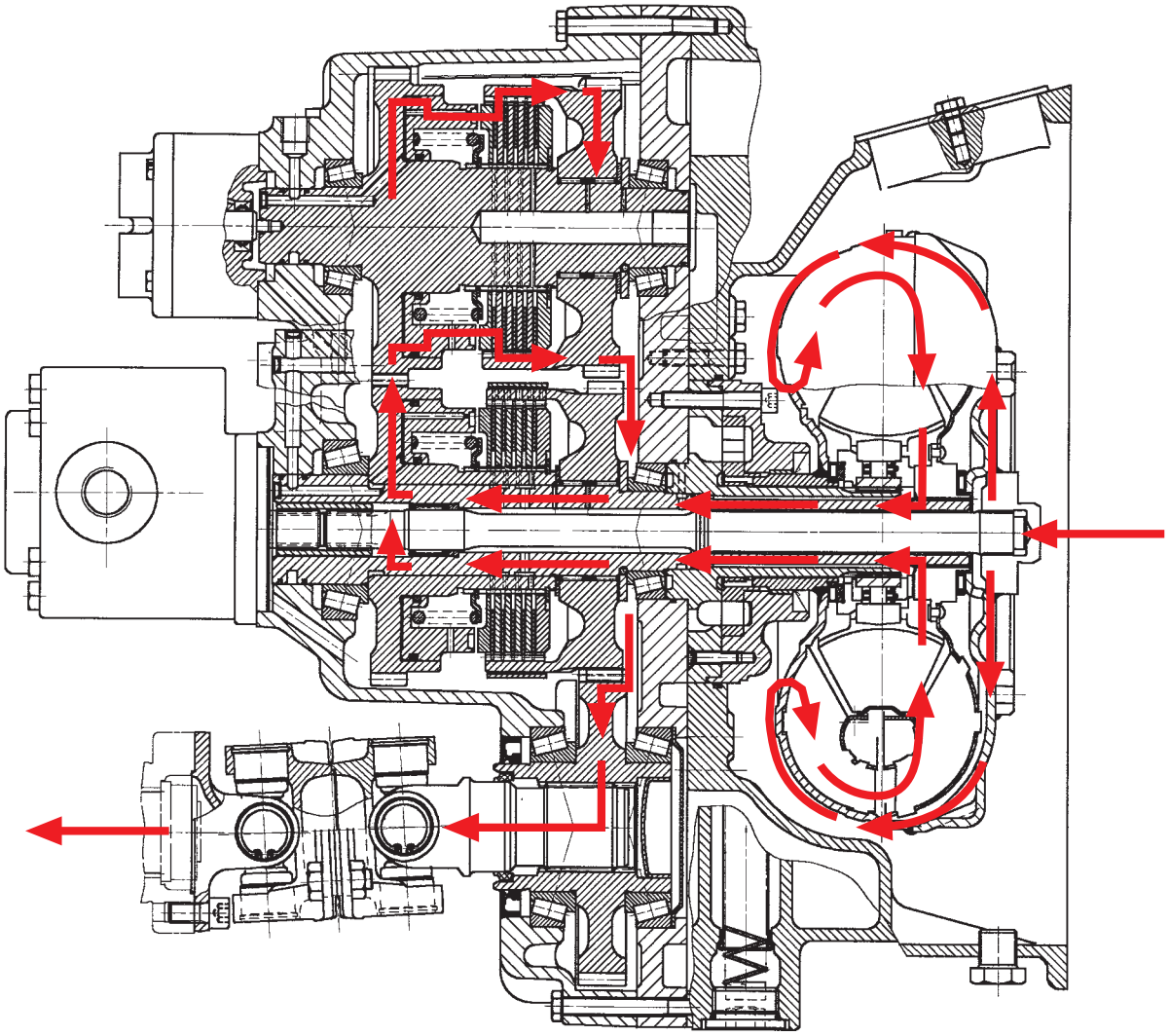
The axle lubrication (16) pump engages in and is driven by the reverse shaft. It always operates when the engine rotates, but rotating speed varies with torgue converter output.

## Transmission Power Flow – Forward



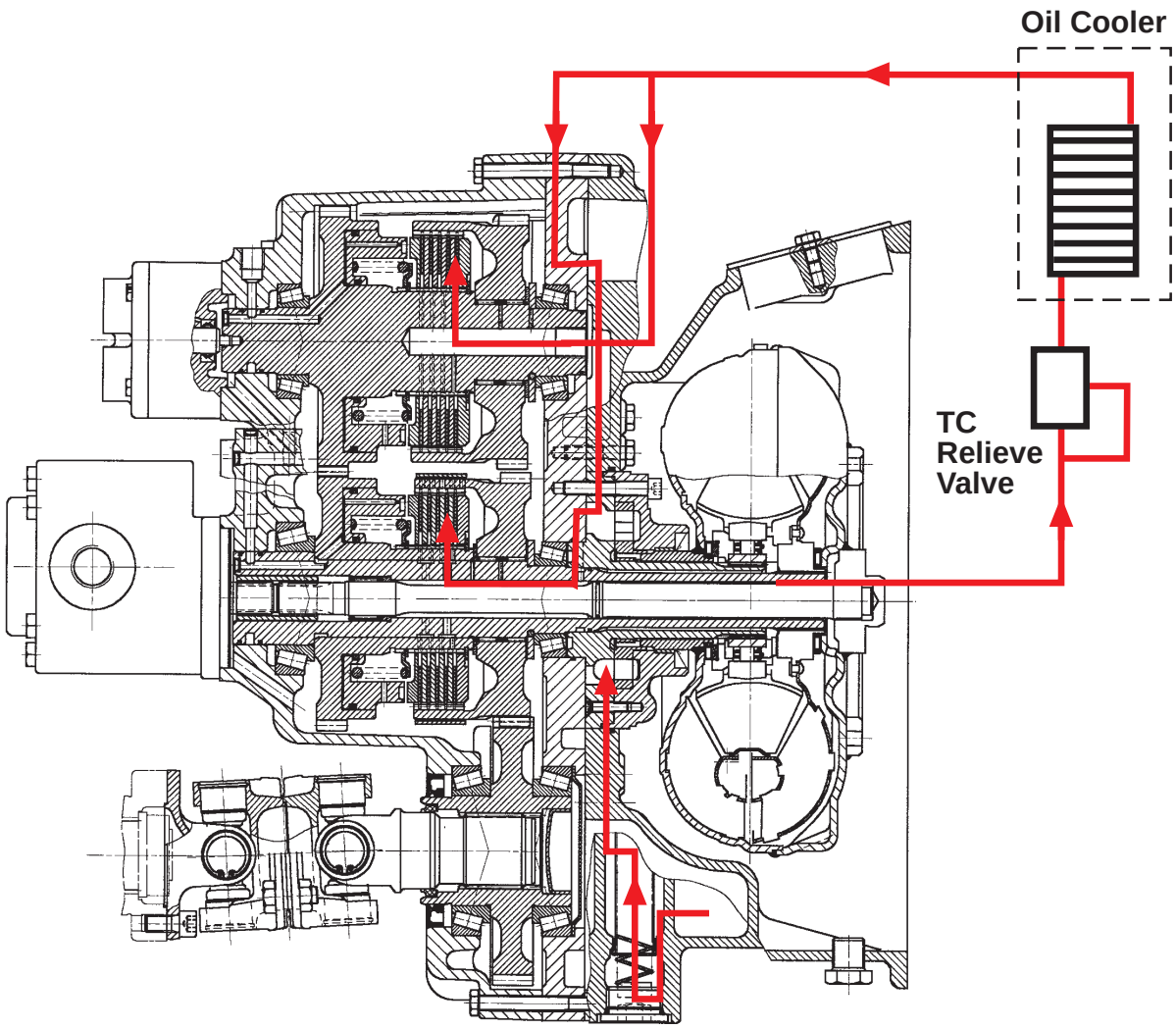
With the transmission control in forward, which will pressurize the forward clutch (8), power will flow from the engine through the torque converter to drive the oil pump (6) and the input shaft (5), also the quill shaft (14). Since the forward clutch (8) locks the forward gear (7) to the input shaft, the power flows through the forward clutch (8), the forward gear (7) to output gear (12) which is in mesh with the forward gear. The u-joint (13) which is splined to the output gear will transmit power to the axle.

## Transmission Power Flow – Reverse



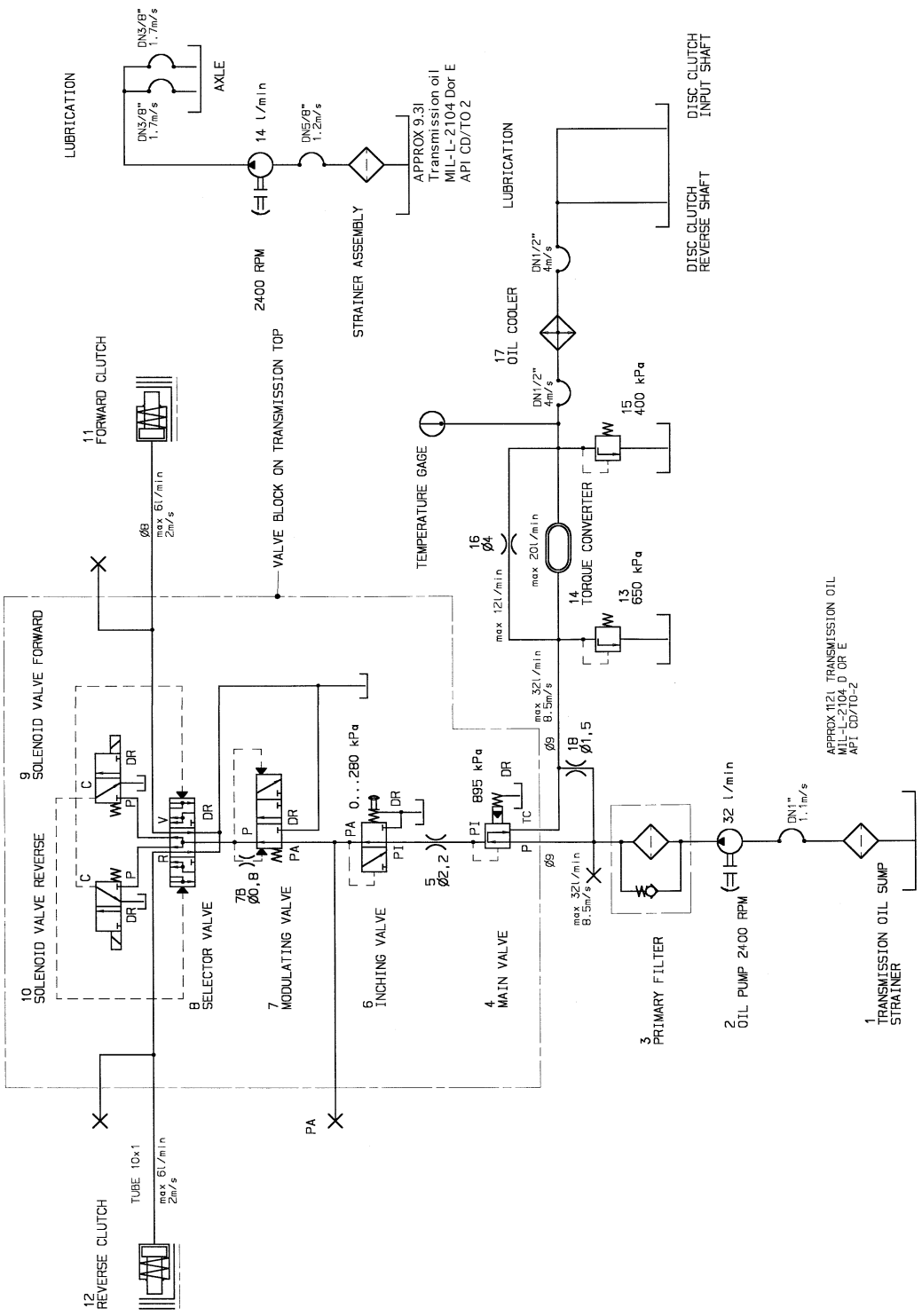
With the transmission controls in reverse, which will pressurize the reverse clutch (10), power will flow from the engine through the torque converter to drive the oil pump (6) and the input shaft (5) also the quill shaft (14). Since the reverse clutch (10) is closed, power will flow through input shaft gear (5A) which is in mesh and drives reverse shaft gear (9A) and reverse shaft (9). The reverse gear (11) which is locked to the reverse shaft by the reverse clutch (10) is in mesh and drives the output gear (12). The U-joint, which is splined to the output gear will transmit power to the axle.

## Transmission Lubrication Schematic

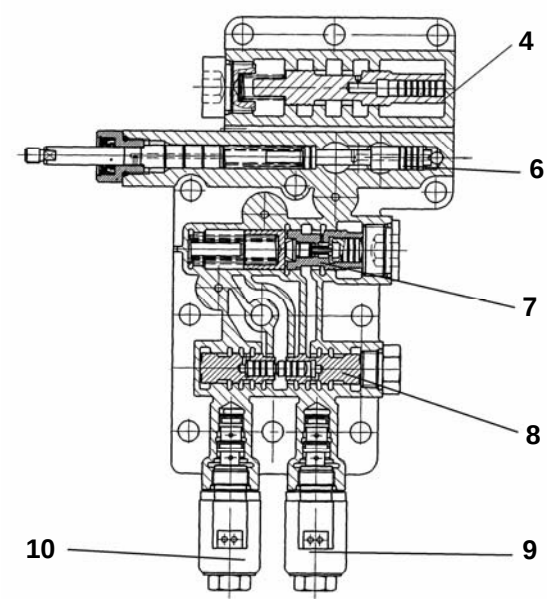



Oil for lubrication of the clutch shaft bearings and cooling the clutch discs and plates comes from the outlet passage of oil cooler. Lubrication oil is also splashed inside the transmission case. Lubrication oil is especially important for cooling the clutches.
High temperatures can be caused during repeated shifting of the lift truck.

## Transmission Hydraulic System




(1) Transmission Oil Sump. (2) Oil Pump. (3) Primary Filter. (4) Main Valve. (5) Orifice. (6) Inching Valve. (7) Modulating Valve. (7A) Load Piston. (7B) Modulating Valve Orifice. (8) Selector Valve. (9) Solenoid Valve Forward. (10) Solenoid Valve Reverse. (11) Forward Clutch. (12) Reverse Clutch. (13) Relief Valve. (14) Torque Converter. (15) Relief Valve. (16) Converter Bypass. (17) Oil Cooler. (18) Torque Converter Supply Bypass.




The basic components of the hydraulic system for operating the transmission are transmission oil sump (1), oil pump (2), primary oil filter (3), valve block, containing main valve (4), orifice (5), inching valve (6), modulating valve (7), selection valve (8), forward and reverse solenoid valves (9,10), forward clutch (11), reverse clutch (12), torque converter (14) with relief valves (13,15), bypass (16) and oil cooler (17). The pump is located in the torque converter housing, and valve block is located on top of transmission, the filter is located on the right hand of the transmission housing.

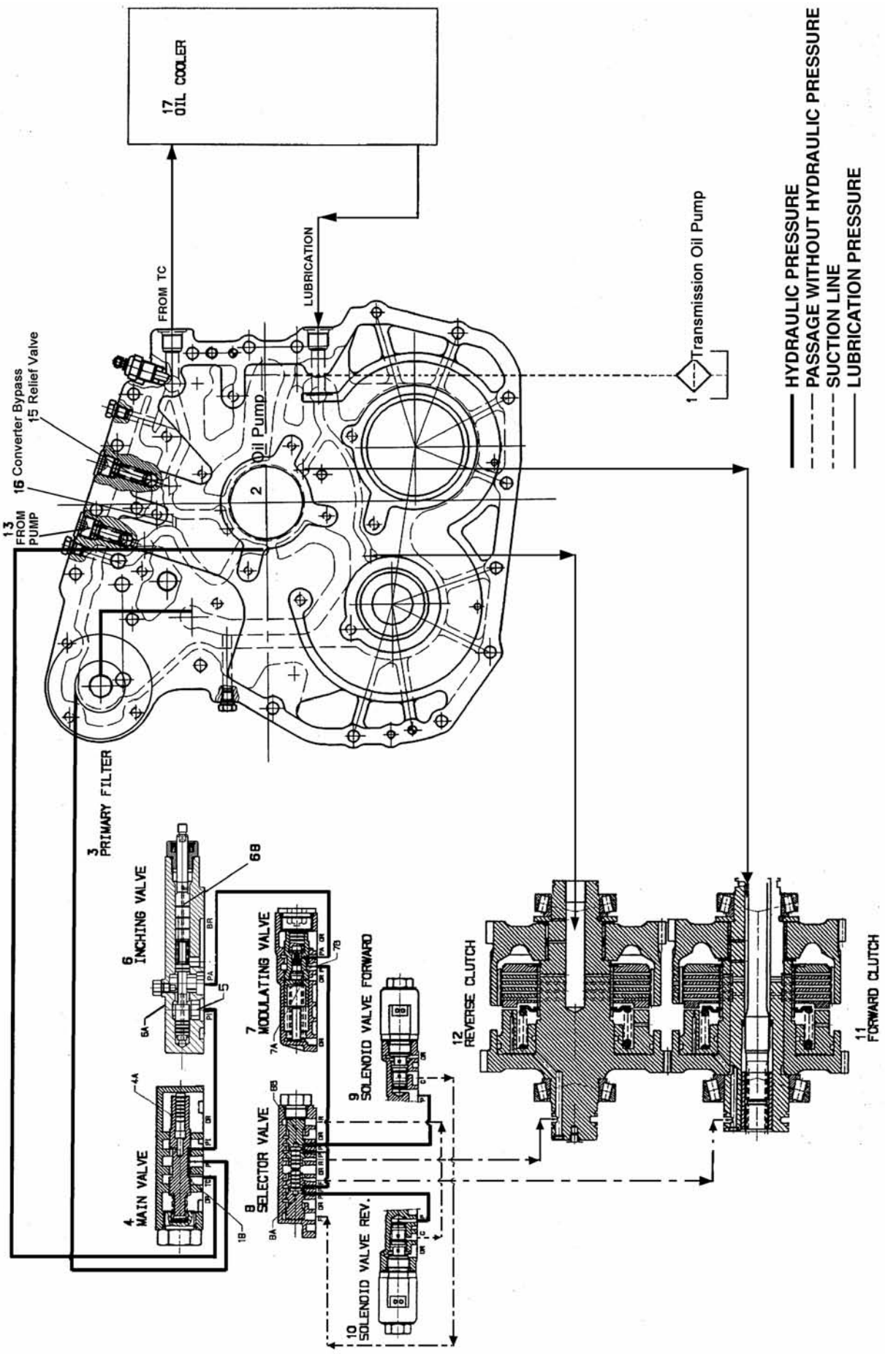
The transmission hydraulic system is explained in three sections. The first section is the oil pump, filter, torque converter and oil cooler systems. The second section is the transmission lubrication system. The third section is the transmission hydraulic control system which controls the lift truck direction control.

**Pump, Filter, Torque Converter and Oil Cooler Systems**

The oil for the operation and lubrication of the transmission is made available by pump (2). The pump is located in the torque converter housing and is driven by Tangs on the torque converter neck.

Oil sump (1), for the transmission, is in the bottom of the transmission case. Oil from reservoir flows through the strainer and internal channels to the suction side of positive displacement pump .

Oil from pump (2) flows to primary oil filter (3). If there is a restriction in the oil filter or if the oil is cold and thick, a bypass valve in the filter will open. The difference in pressure at which the bypass valve will open is 124 ± 7 kPa (18 ± 1 psi). From the primary oil filter, the oil flows on to main relief valve (4). In the spool of main relief valve there is a bypass (18). The purpose of this bypass is to supply lubrication and coolant oil to the torque converter at low speeds and especially during hot oil conditions. Converter relief valve (13) protects the torque converter from oil pressure higher than 670 kPa (97 psi), such as during cold oil start-ups. At this pressure, the oil is released back to the reservoir. Converter inlet passage has converter bypass orifice (16). The purpose of this orifice is to prevent too much of a pressure load on the torque converter by allowing some of the oil to bypass the converter. In converter outlet passage, there is cooler bypass valve (15). Cooler bypass valve (15) will release oil back to the reservoir if the oil pressure reaches 400 kPa (58 psi). This can happen if the oil cooler has a restriction or if the oil is cold and thick.


17 OIL COOLER
FROM TC
LUBRICATION
1 Transmission Oil Pump
HYDRAULIC PRESSURE
PASSAGE WITHOUT HYDRAULIC PRESSURE
SUCTION LINE
LUBRICATION PRESSURE
15 Relief Valve
16 Converter Bypass
13 FROM PUMP
2 Oil Pump
3 PRIMARY FILTER
6 INCHING VALVE
6B
7 MODULATING VALVE
9 SOLENOID VALVE FORWARD
12 REVERSE CLUTCH
11 FORWARD CLUTCH
4 MAIN VALVE
8 SELECTOR VALVE
10 SOLENOID VALVE REV.

**Neutral Position**

When the transmission is in NEUTRAL position with the engine running, oil is pulled from reservoir and the strainer assembly (1) to pump (2). From there, pump oil flows through the primary filter (3) to main relief valve (4). Oil will also flow through orifice (18) to lubricate the torque converter during hot, low speed conditions.

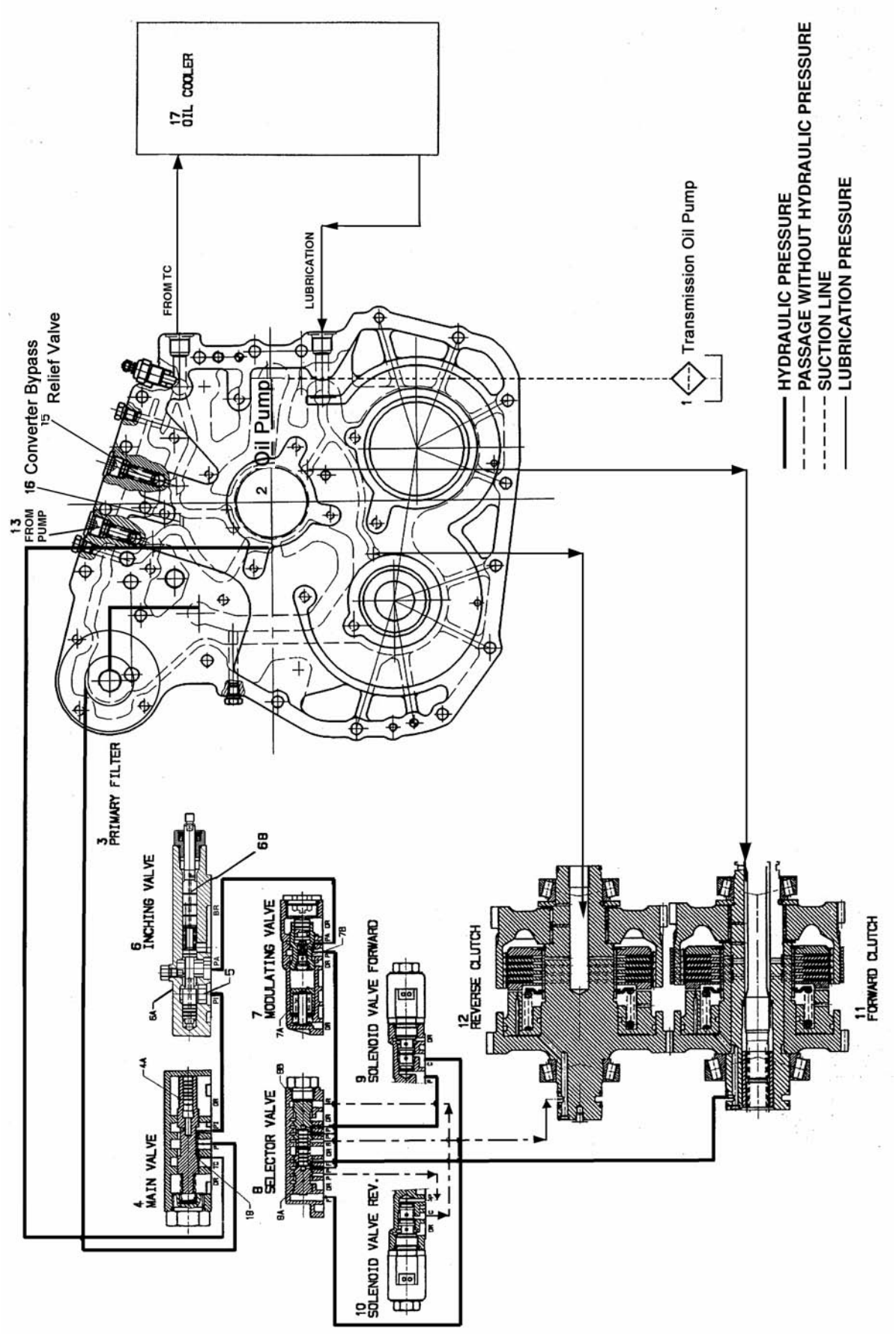
When the pump pressure reaches 895 kPa (130 psi), relief valve spool (4A) will move to the left side and most of the pressure oil flows to the torque converter.

Spool will move left and right to maintain 895 kPa (130 psi). Oil can also bypass the torque converter through converter bypass orifice (16). The purpose of orifice (16) is to prevent too much of a pressure load being put on the torque converter.

Oil flows from the torque converter through a passage to oil cooler (17). Oil then flows back to transmission to cool and lubricate the clutches and shaft bearings.

In NEUTRAL position, the remaining pressure oil flows from main relief valve (4) to inching valve (6).
Without inching (inching pedal up and valve in), oil flows around and through the center of spool (6A) to the bottom of the spool. The oil, at the bottom, pushes the spool to the position shown. Oil flows around the lands of the spool and through a passage to modulating valve (7).

In NEUTRAL position, forward solenoid (9) and reverse solenoid (10) are OFF. Pump oil flow is blocked at the solenoids. Oil cannot flow through oil passage to the forward or reverse selector spool. Pump oil pressure is felt at slugs. This forces forward selector spool to the right and reverse selector spool to the left. With the spools in this position, forward clutch (11) and reverse clutch (12) are open to drain. Most of the oil still flows through the lube circuit.


17 OIL COOLER
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Transmission Oil Pump
HYDRAULIC PRESSURE
PASSAGE WITHOUT HYDRAULIC PRESSURE
SUCTION LINE
LUBRICATION PRESSURE
15 Converter Bypass Relief Valve
16
13 FROM PUMP
2 Oil Pump
3 PRIMARY FILTER
6 INCHING VALVE
6B
7 MODULATING VALVE
9 SOLENOID VALVE FORWARD
12 REVERSE CLUTCH
11 FORWARD CLUTCH
4 MAIN VALVE
8 SELECTOR VALVE
10 SOLENOID VALVE REV.

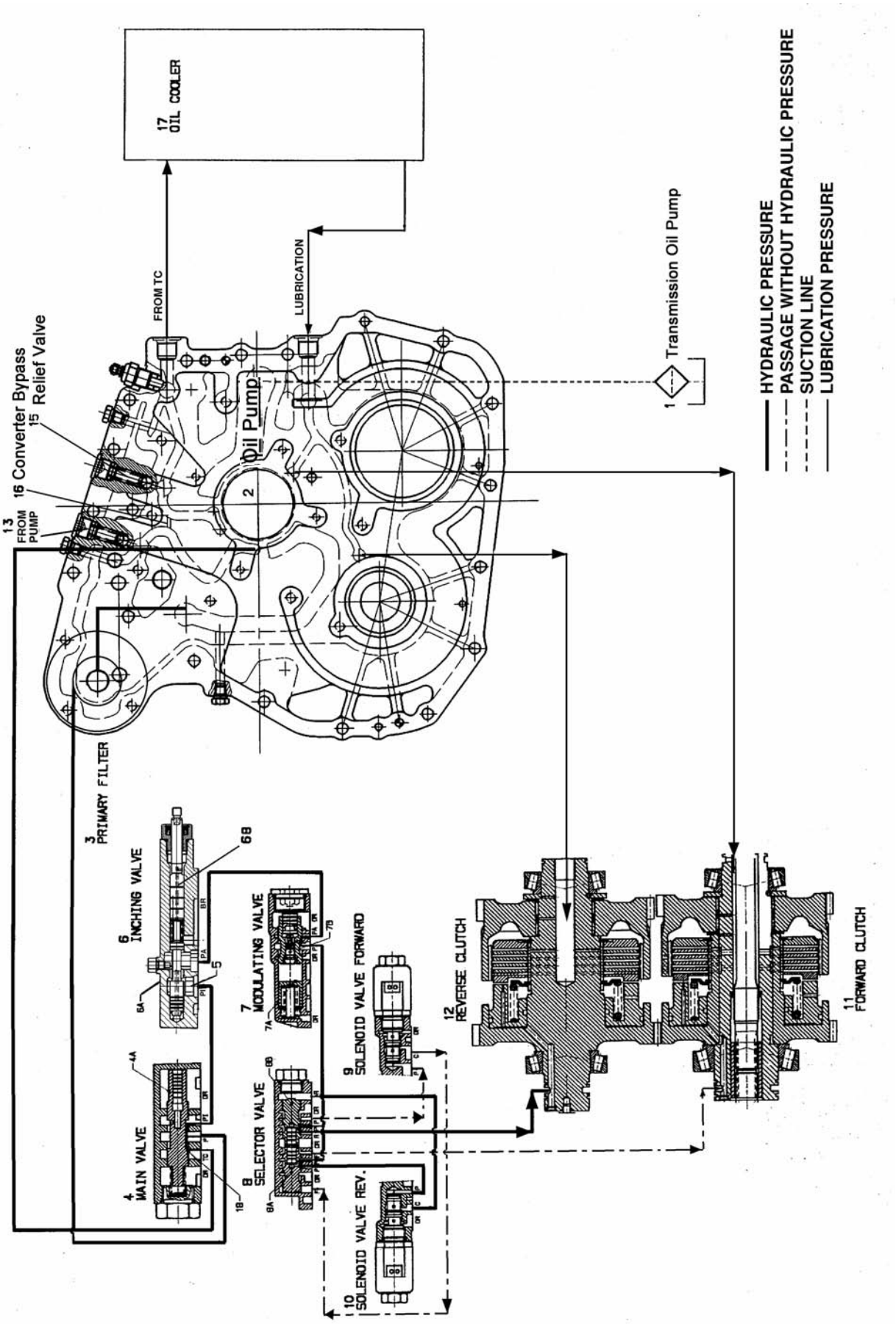
**Forward Direction**

When the transmission is in FORWARD, the oil flow from the reservoir, through the pump, primary filter, torque converter and oil cooler circuits will be the same as explained in NEUTRAL position.

Oil will flow from the main relief valve to inching valve (6). Without inching (inching pedal up and valve in), oil flows around and through the center of reducing spool (6A) to the bottom of the spool. The oil, at the bottom, pushes the spool up to the position shown. Oil flows around the lands of the spool and through a passage to modulating valve group (7).

In FORWARD, forward solenoid (9) is ON, so pump oil is sent to the forward selector spool through oil passage. Forward selector spool (8A) moves to the right, causing reverse selector spool (8B) to move to the right also.

With the reverse spool in this position, reverse clutch (12) is open to drain, Forward selector spool (8A) opens forward clutch (11) to pump oil. This also opens reverse selector spool (8B) to drain through oil passage. Forward clutch (11) will fill with pump oil. Once filled, oil pressure begins to build up. Pump oil goes through orifice (7B) and moves load piston (7A) to the left as pump pressure increases. Oil pressure increases as the load piston moves further to the left. The pressure increases to the control pressure of 895 kPa(130 psi). Forward clutch(11) will now be fully engaged. Modulating valve assembly(7) will now shuttle between pump oil and drain to maintain clutch pressure. Clutch fill time takes 0.4 seconds and pressure increase takes 0.7 seconds.This approximate 1.1 second clutch fill and pressure rise time, gives a cushion engagement of forward clutch (11).


17 OIL COOLER
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3 PRIMARY FILTER
6 INCHING VALVE
6B
6A
5
7 MODULATING VALVE
7B
7A
9 SOLENOID VALVE FORWARD
12 REVERSE CLUTCH
11 FORWARD CLUTCH
4A
4 MAIN VALVE
1B
8B
8 SELECTOR VALVE
8A
10 SOLENOID VALVE REV.

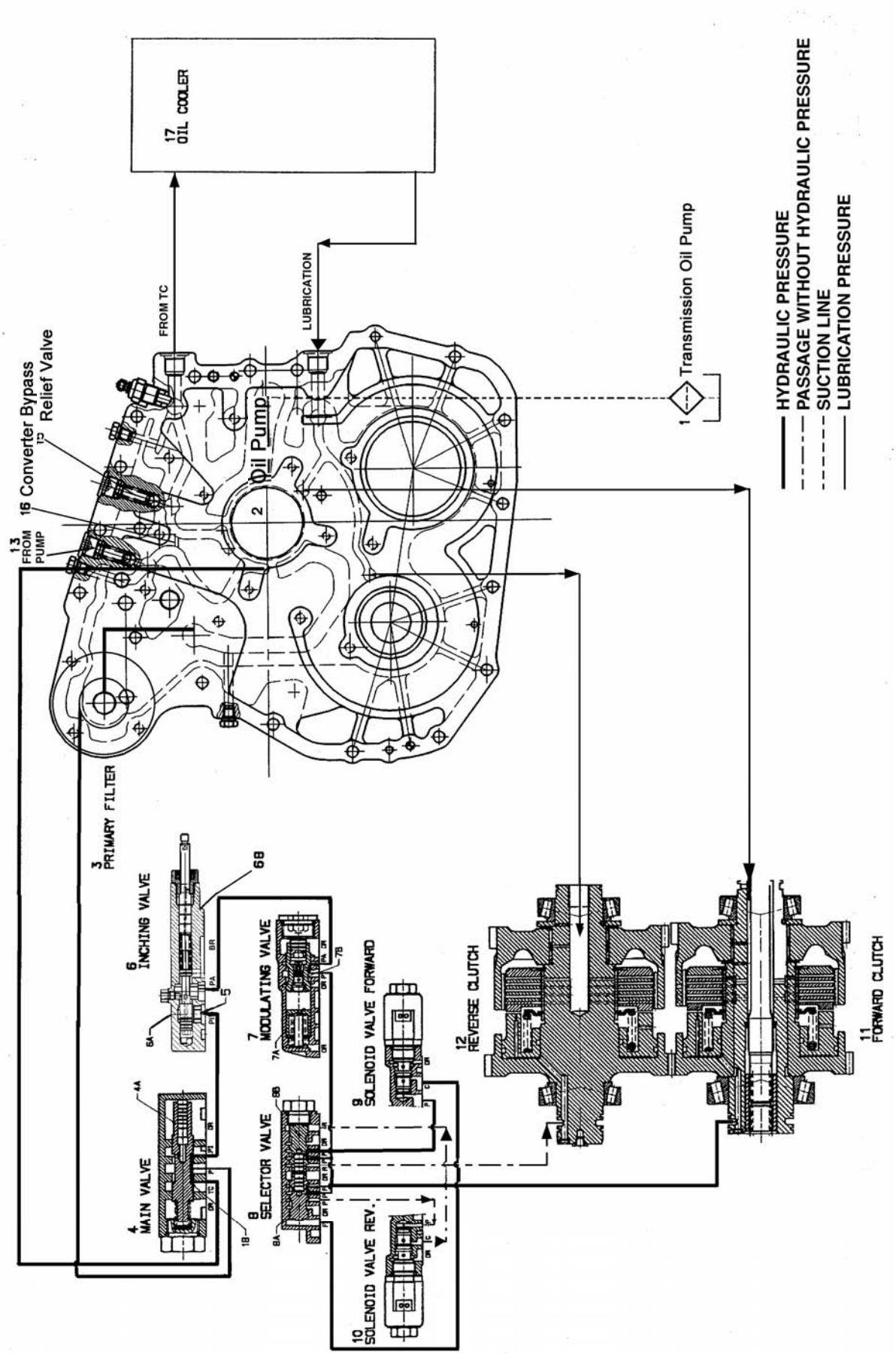
**Reverse Direction**

When the transmission is in REVERSE, the oil flow from the reservoir, through the pump, primary filter, torque converter and oil cooler circuits will be the same as explained in NEUTRAL position.

Oil will flow from the main relief valve to inching valve (6). Without inching (inching pedal up and valve in), oil flows around and through the center of reducing spool (6A) to the bottom of the spool. The oil, at the bottom, pushes the spool up to the position shown. Oil flows around the lands of the spool and through a passage to modulating valve group (7).

In REVERSE, reverse solenoid (10) is ON, so the pump oil is sent to the reverse selector spool through an oil passage. Reverse selector spool (8B) moves to the left, causing forward selector spool (8A) to move to the left also.

With the forward selector spool in this position, forward clutch (11) is open to drain. Reverse selector spool (8B) opens reverse clutch (12) to pump oil. This also opens forward selector spool (8A) to drain through passages. Reverse clutch (12) will fill with pump oil. Once filled, oil pressure begins to build up. Pump oil goes through orifice (7A) and moves load piston (7A) to the left as pump pressure increases. Oil pressure increases as the load piston moves further to the left. The pressure increases to the control pressure of 895 kPa(130psi). Reverse clutch (12) will now be fully engaged. Modulating valve assembly(7) will now shuttle between pump oil and drain to maintain clutch pressure. Clutch fill time takes 0.4 seconds and ressure increase takes 0.7 seconds. This approximate 1.1 second clutch fill and pressure rise time, gives a cushion engagement of reverse clutch (12).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6 INCHING VALVE
6B
7 MODULATING VALVE
9 SOLENOID VALVE FORWARD
12 REVERSE CLUTCH
11 FORWARD CLUTCH
4 MAIN VALVE
8 SELECTOR VALVE
10 SOLENOID VALVE REV.

**Forward Direction During Inching**

When the transmission is in FORWARD (or REVERSE) during INCHING, the oil flow from the reservoir, through the pump, filter, torque converter and oil cooler circuits will be the same as explained in NEUTRAL position.

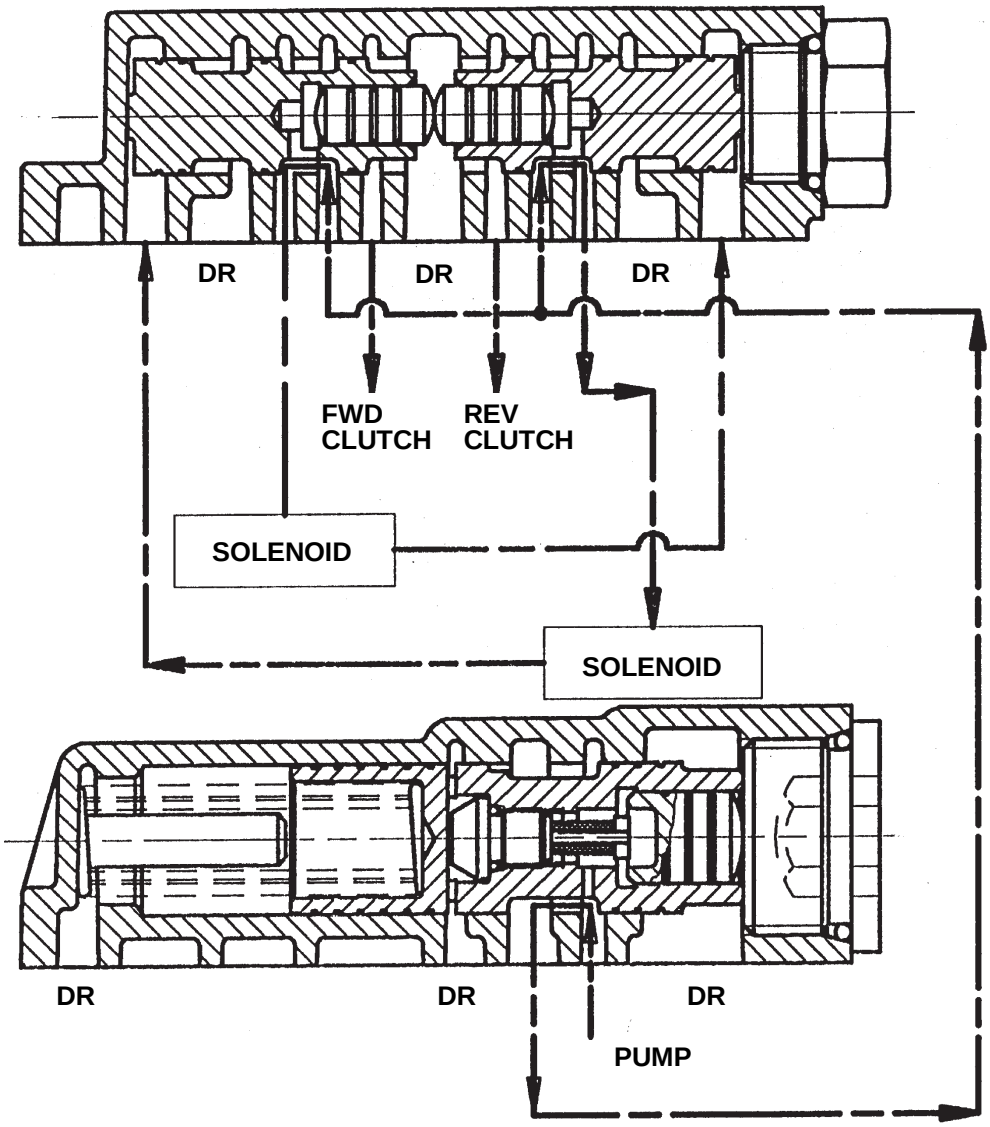
Oil will flow from the main relief valve through a passage, to inching valve (6). Inching valve (6) lets the operator control the oil pressure to forward clutch (11) between 280 and 0 kPa (40 and 0 psi), which permits a partial engagement of the clutch. Through the use of the inching valve, the lift truck can move slowly while the engine is at higher speeds. This lets the operator move the lift truck slowly up to a load while the mast is raised rapidly.

When the operator pushes the inching pedal part of the way down, inching plunger (6B) moves out of the inching valve. This takes away some of the spring force between plunger (6B) and reducing spool (6A). It also removes the balance condition between the pump pressure, at the bottom of spool (6A), and the spring force. Reducing spool (6A) moves to the right, which causes a restriction for the pump oil flow. The pressure drops from 895 kPa (130 psi) to 280 kPa (40 psi). The pressure can drop further depending on the position of plunger (6A). Pressure reduces as plunger (6A) is moved out (as the inching pedal is pushed down).

This reduced pressure flows to selector valve group (8). The oil will flow through the valve as explained in forward direction. The reduced (inching) pressure will flow through a passage to partially engage forward clutch (11). This reduced pressure permits slippage of the forward clutch plates and discs. Therefore, the truck will have an operator controlled movement. The amount of oil pressure to clutch (11) depends on the position of inching plunger (6A). As the plunger is pulled out completely (inching pedal all the way down) clutch pressure will drop to 0 kPa (0 psi). The forward clutch will be disengaged at approximately 65.5 kPa (9.5 psi).

## Transmission Control Valve

**Basic Control Schematic**




The control schematic is shown below. The system consists of 2 valve bores:
1. Modulating valve
2. Forward and reverse selector valves

**Modulating valve function**

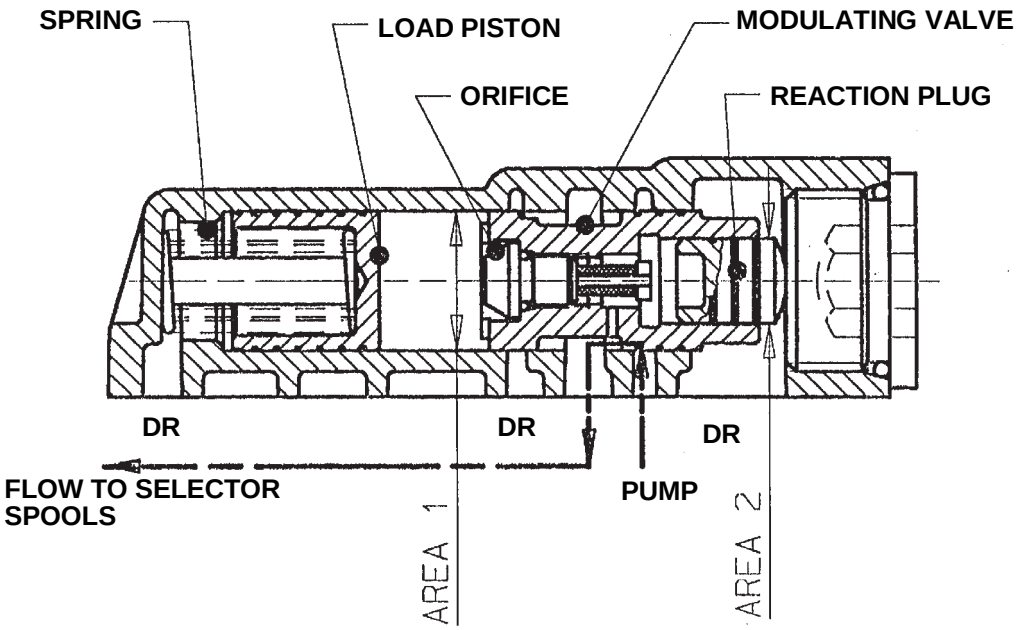



**Figure 1**

The modulating valve consists of 5 basic elements:
1. Orifice
2. Springs
3. Load piston
4. Modulating valve
5. Reaction slug

The function of the modulating valve is to control clutch pressure during a shift. It allows the clutch pressure to raise gently to the maximum transmission pressure in order to provide a smooth clutch engagement and a good shift feel for the vehicle operator.
There are two forces acting on the modulation valve:

Force 1 = Pressure (load piston) / Area 1
Force 2 = Pressure (clutch) / Area 2

In order for the modulating valve to stay in a balance position Force 1 must be equal to Force 2.
If for example Force 2 is too large (clutch pressure is too large) then the valve will be forced to the left, shutting off supply and opening the clutch and slug pressure to drain, and reducing Force 2.

If Force 1 is too large then the valve would be forced to the right, opening the clutch circuit to supply,
and increasing the value of Force 2 so it balances Force 1. By regulating clutch pressures between supply and drain, valve forces are balanced.

**Modulating valve movement during clutch fill**

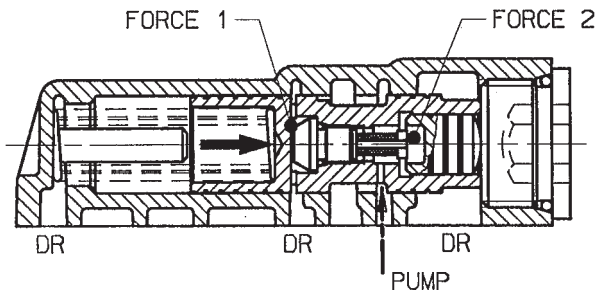



**Figure 2**

When a new direction is selected by the operator, the selector spools open up a circuit to the new clutch piston. System pressure drops as the new clutch piston is stroking. This drop in supply pressure causes a force imbalance on the modulating valve / reaction slug pressure becomes smaller. Since Force 1 is still the same, Force 1 forces the modulating valve to the right until the end of the modulating valve opens the load piston cavity to drain.

The load piston oil dumps to drain and the load piston immediately moves to the right (shown in fig.2).
This action is called "load piston reset". It happens very quickly in comparison to the time needed for the clutch piston to fully stroke. Therefore the modulating valve and load piston are ready to start controlling the clutch pressure in a smooth upward manner once the clutch piston finishes stroking.

**Modulation of clutch to top pressure**

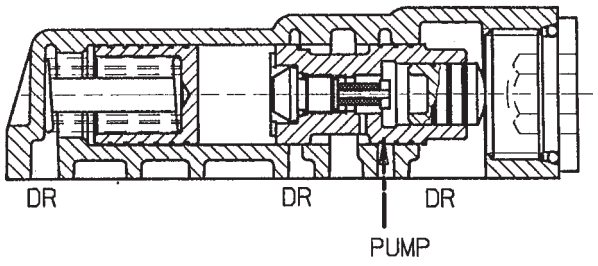



**Figure 3**

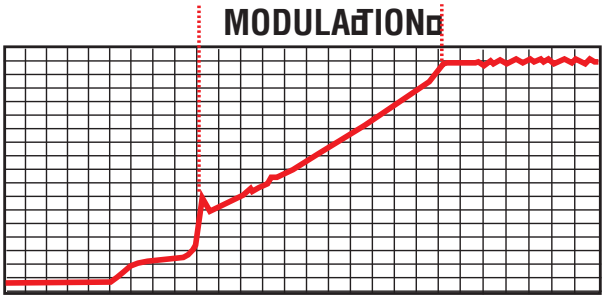



**Figure 4**

As long as reaction slug pressure is greater than load piston pressure, oil will flow across the orifice from Area 2 to Area 1. As oil flows to the load piston the springs will continue to compress, allowing the load piston to move to the left. As the load piston moves to the left the spring force increases and load piston pressure increases.

As press (LP) increases the modulating valve will cause a corresponding increase in clutch pressure in order to keep the forces balanced. In simple terms as the load piston strokes to the left the clutch pressure rises to maximum system pressure.

This controlled rise in clutch pressure takes about 0.7 sec. and is shown in fig.4. It occurs immediately after the clutch piston completely strokes (end of clutch fill).

**Selector spools**

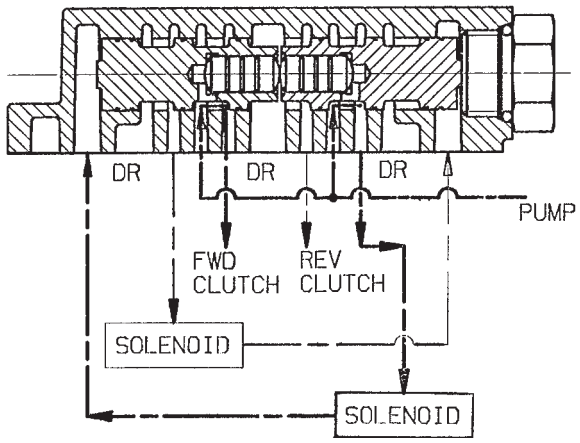



**Figure 5**

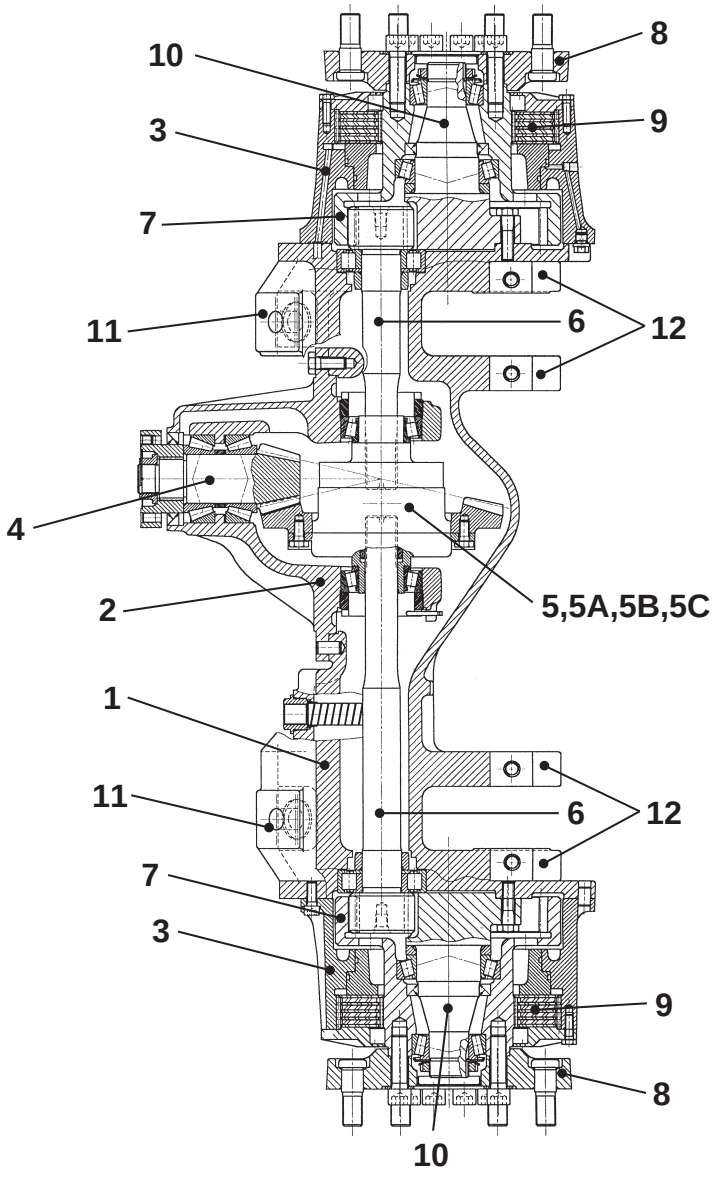
The selector spool circuits are arranged in such a way that once a gear (forward or reverse) is selected the opposite solenoid supply is shut off and drained. This is done to prevent any electrical or malfunction of the other solenoid from giving a sudden and unexpected shift.
In addition the two selector spools are arranged so they cannot select both forward and reverse at the same time because they mechanically interfere with each other.

The selector spools have two areas:
1. Slug area
2. Spool area

The slug cavity is exposed to system pressure all the time. If the solenoid allows system oil to flow to the end of the spool and pressurize the spool area then the spool will move toward the slug because the spool area is larger than the slug area and the force will be higher. When the solenoid is closed, pressure to the spool is reduced. This allows the pressure at the slug to move the spool away from the slug.

In fig.5 the selector spools are shown with forward gear selected. Notice that the reverse solenoid supply is drained through the forward spool.

## Drive Axle




(1) Axle Housing. (2) Carrier (3) Brake Housing Left/Right. (4) Pinion. (5) Crown wheel/differential.
(6) Drive Shaft Left/right. (7) Ring Gear/Hub. left/right. (8) Pneumatic Tire Wheel Flange Left/right. (9) Multi-disc brake left/right. (10) Spindle. (11) Axle Mounting Pads. (12) Mast Mounting Hooks.

The Axle Consists of 4 main sections

a) The carrier housing (2), pinion (4) and crownwheel with differential assembly (5).

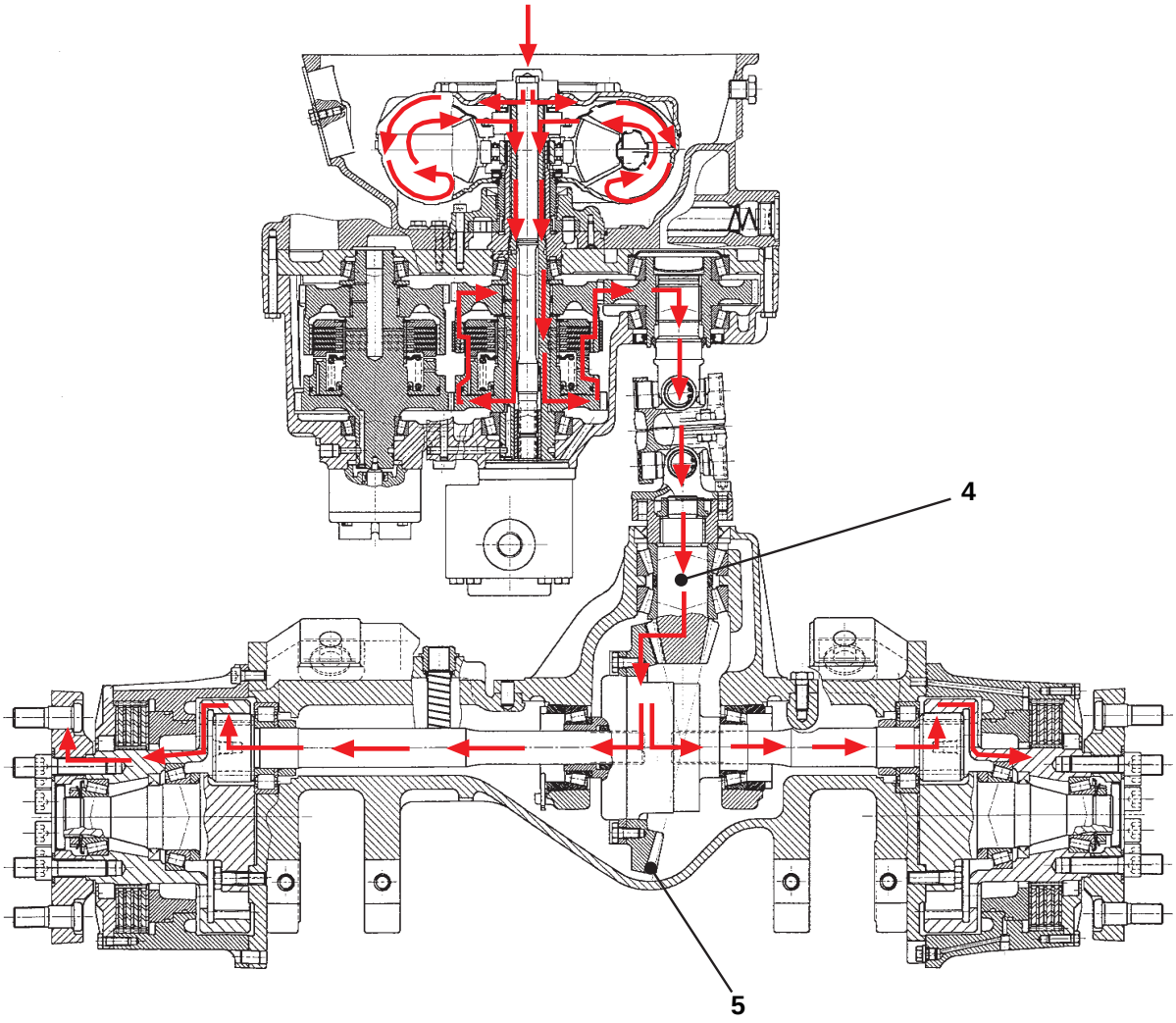
b) The axle housing with left and right drive shaft (6), mounting pads (11) and mast mounting hooks (12).

c,d) Hub section left and right with ring gear (7), wheel flange (8), spindle (10) and multi-disc brake (9).

Wheel flange (8) used with pneumatic tire trucks only.

## Axle power flow

Power is transmitted by the transmission output shaft to the pinion (4) which meshes with and drives the crownwheel (5), which is mounted to the differential.



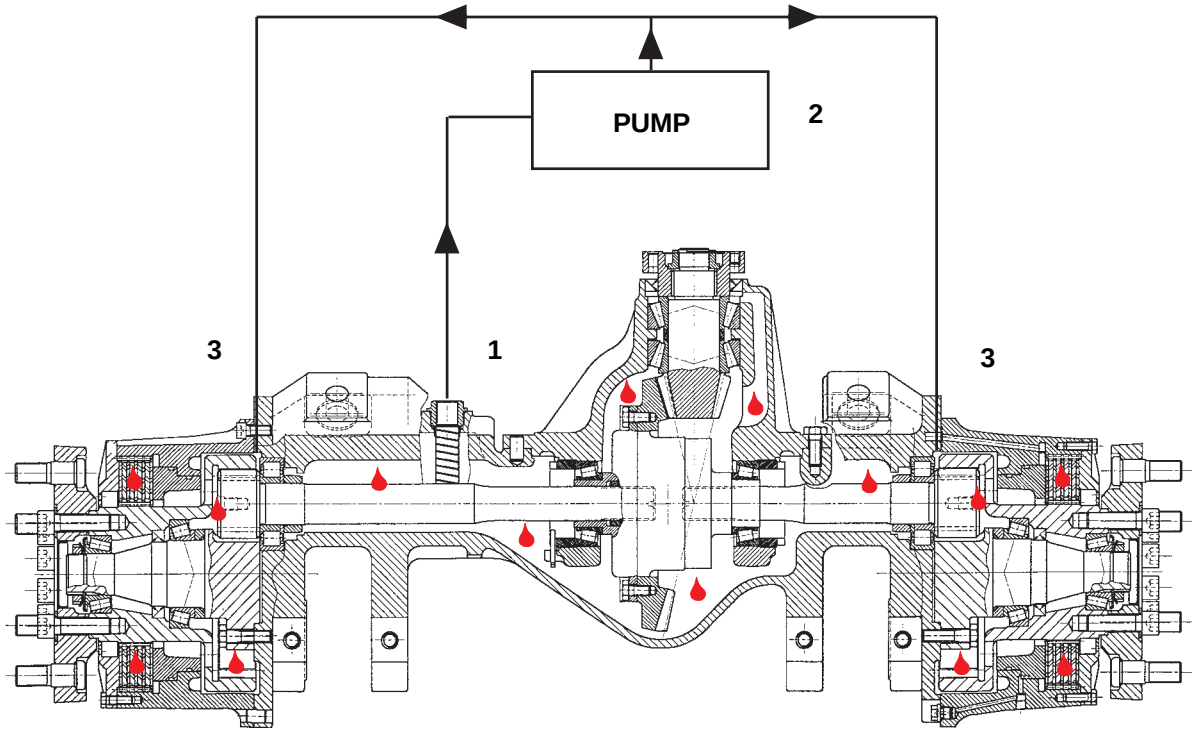

The differential is part of the drive axle. It is a single reduction unit with a differential drive gear fastened on the differential case.

The differential is used to send the power from the transmission to the wheels. When one wheel turns slower than the other, the differential lets the inside wheel stop or turn slower in relation to the outside wheel.

Differential case (5A) has four differential pinion gears (5B) on the differential pinion shaft. The pinion gears are engaged with two side gears (5C). The side gears are splined to the axle shafts.

When the lift truck moves in a forward direction and there is the same traction under each wheel, torgue in each axle and pinion gears (5B) are balanced. Both left and right axles roatate the same. During a turn, the force(traction) that is on the drive wheels is different. These different forces are also felt on opposite sides of the differential and cause pinion gears (5) to turn. The rotation of pinion gears (5) stops or slows the inside wheel and lets the outside wheel go faster. This moves the machine through a turn under full power.
The differential gets lubrication from oil thrown about inside the housing.

## Axle Lubrication Schematic




The axle is lubricated by means of the transmission-mounted lubricant pump (2) which gets oil from the axle suction port (1) and supplies it to the hub section pressure parts (3) to lubricate and cool hub drive and multi-disc brakes.
Oil returns to the sump through the drive shaft bearings and axle housing.

# Testing and Adjusting

## Troubleshooting

Troubleshooting can be difficult. A list of possible problems and corrections is on the pages that follow.

This list of problems and probable causes will only give an indication of where a problem can be and what repairs are needed. Normally, more or other repair work is needed beyond the recommendations on the list. Remember that a problem is not necessarily caused only by one part, but by the relation of one part with other parts. This list cannot give all possible problems and probable causes. The serviceman must find the problem and its source, then make the necessary repairs.

Always make visual checks first. Check the operation of the machine and then check with instruments.

**⚠ WARNING**

**To prevent personal injury, when testing and adjusting the power train, move the machine to an area clear of obstructions. There must be adequate ventilation for the exhaust. When drive wheels are off the ground for testing, keep away from wheels that are in rotation.**

Operate the machine in each direction. Make note of all noises that are not normal and find their source. If the operation is not correct, make reference to the troubleshooting chart for "problems" and "probable causes"

### Visual Checks

**1.** Check the oil level in the transmission and axle with the engine running and with the Transmission in NEUTRAL.

**2.** Check all oil lines, hoses and connections for leaks and damage. Look for oil on the ground under the machine.

**3.** Actuate the controls for the forward direction and then for the reverse direction. The actuation must give the same positive action to the hydraulic control circuit for clutch engagement in both directions.

**4.** Remove and check the filter element for loose particles. Check the strainer behind the transmission oil plug for foreign material.

**a.** Particles of friction material give an indication of a clutch failure.

**b.** Metallic (metal) particles in the filter give an indication of wear or mechanical failure in the transmission and/or axle.

**c.** Rubber particles give an indication of seal or hose failure.

If metal or rubber particles are found, all components of the transmission hydraulic system must be flushed. Make a replacement of all parts that show damage.

**NOTICE**

Before these checks are started, fill the transmission and axle with oil to the correct level. See the Operation & Maintenance Manual for the procedure to check transmission and axle oil level.

Activate the controls for the FORWARD direction and then for the REVERSE direction. The modulation will be seen on pressure gauge in the clutch pressure tap when the shift is made at low idle. The pressure will increase to 895 kPa (130 psi) when completely filled.

Operate the machine in each direction. Make note of noises that are not normal and find their source. If the operation is not correct, make reference to the check List During Operation for "problems" and "probable causes".

## Check List during Operation

**Problem: Engine starts with directional control switch in FORWARD or REVERSE.**

**Probable cause:**

**1.** Directional control switch is defective

**Problem: Transmission shifts with parking brake engaged.**

**Probable cause:**

**1.** Parking brake switch is defective.

**Problem: Transmission will not stay in gear when shifted.**

**Probable cause:**

**1.** Parking brake switch mounting is loose.

**Problem: Transmission does not operate in either direction or does not shift.**

**Probable cause:**

**1.** Problems in the electrical circuit (directional control)

- **a.** Open circuit between ignition switch and directional control switch.
- **b.** Defective directional control switch.
- **c.** Defective wiring harness between directional control switch and transmission.
- **d.** Shorted wiring harness for the solenoids.

**2.** Low oil pressure or no oil pressure caused by:

- **a.** low oil, no oil or thick oil.
- **b.** Inching control valve linkage loose, broken or adjustment is not correct.
- **c.** Inching valve reducing spool stuck open.
- **d.** Failure of the oil pump or a defect in the oil pump.
- **e.** Main relief valve stuck open.
- **f.** Restriction in the oil flow circuit such as dirty oil screen.
- **g.** Leakage inside the transmission.
  Worn or broken metal seal rings on input or reverse shaft.
  Worn or broken seals around clutch piston.
  Modulating valve assemblies stuck
  Because of contaminated oil

**3.** External oil lines are not connected correctly.

**4.** Mechanical failure in the transmission.

**Problem: Transmission operates only in FORWARD.**

**Probable cause:**

**1.** Forward clutch is locked up.

**2.** Reverse solenoid valve does not actuate.

**3.** Reverse clutch components have damage.

- **a.** Leakage caused by worn or broken metal sealing rings.
- **b.** Leakage caused by worn or broken clutch piston.
- **c.** Failure of shaft seal ring.

**Problem: Transmission operates only in REVERSE.**

**Probable cause:**

**1.** Reverse clutch is locked up.

**2.** Forward solenoid valve does not actuate.

**3.** Forward clutch components have damage.

- **a.** Leakage caused by worn or broken metal sealing rings
- **b.** Leakage caused by worn or broken seal around clutch piston.
- **c.** Failure of shaft seal ring.

**Problem: Transmission gets hot.**

**Probable cause**:

**1.** Restriction in cooling circuit.

**2.** Oil level too high or too low.

**3.** Core of the oil cooler not completely open.

**4.** Low pump pressure - worn or damaged pump.

**5.** Converter one-way clutch worn and slipping.

**6.** Air mixed in the oil. Air leaks on the intake side of the pump.

**7.** Low oil flow through converter. Converter relief valve stuck open (converter bypass orifice plugged)

**8.** Incorrect use of vehicle. Loads are too heavy for the lift truck.

**9.** Too much inching operation (slipping the clutch plates and discs).

**10.** Too much stalling of torque converter.

**11.**Cooler relief valve stuck open, full oil flow does not go through oil cooler.

**Problem: Clutch engagement is slow or loss of power during engagement.**

**Probable cause:**

**1.** Low oil pressure

**2.** Air mixed in the oil.

**a.** Air leaks on suction side of pump.

**b.** Low oil level also causes aeration.

**3.** Inching valve linkage adjustment is not correct.

**4.** Modulating valve assembly leaks or partially stuck.

**Problem: Clutch engagement makes a rough shift.**

**Probable cause:**

**1.** Modulating valve assembly, load piston and/or reducing valve stuck.

**Problem: Vehicle operates in one direction and creeps in that direction in NEUTRAL. Engine stalls when shifted to the other direction.**

**Probable cause:**

**1.** Failure of clutch in the direction the lift truck moves. Clutch discs or plates are warped (damaged) or held together because of too much heat.

**2.** Failure of the modulating valve assembly in the direction the lift truck moves. The valve assembly stuck in the engaged position possibly caused by metal burrs (particles) or oil contamination.

## Check List from Operation Noise

**Problem: Noise in NEUTRAL only.**

**Probable cause:**

**1.** Worn one-way clutch in torque converter.

**2.** Low oil level (pump cavitation).

**3.** Worn bearing next to pump.

**Problem: Pump noise not normal**

**Probable cause:**

**1.** A loud sound at short time periods gives an indication that foreign material is in the transmission hydraulic system.

**2.** A constant loud noise is an indication of pump failure.

**Problem: Noise in the Transmission that is not normal.**

**Probable cause:**

**1.** Transmission components have wear or damage.

**a.** Damaged gears.

**b.** Worn teeth or clutch plates and/or clutch discs.

**c.** Slipping clutch plates and disc noise.

**d.** Other component parts have wear or damage.

**e.** Failure of the thrust washers.

**2.** Modulating valve assembly makes noise.

**Problem: Constant noise in the Drive axle.**

**Probable cause:**

**1.** Lubricant not to the specific level.

**2.** Wrong type of lubricant.

**3.** Wheel bearings out of adjustment or have a defect.

**4.** Bevel gears not in adjustment for correct tooth contact.

**5.** Teeth of bevel gear have damage or wear.

**6.** Too much or too little gear backlash.

**7.** Loose or worn pinion bearings.

**8.** Loose or worn shaft bearings.

**9.** Loose or worn differential bearings.

**Problem: Noise at different intervals.**

**Probable cause:**

**1.** Bolts on drive gear not tightened correctly.

**2.** Drive gear has a defect (warped).

**3.** Loose or broken differential bearings.

**4.** Bevel gear bearing failure.

**Problem: Noise on turns only**

**Probable cause:**

**1.** Differential pinion gears too tight on the spider or the pinion shaft.

**2.** Side gears tight in differential case.

**3.** Differential pinion or side gears have a defect.

**4.** Thrust washers worn or have damage.

**5.** Too much clearance (backlash) between side gears and pinion.

**6.** Worn axle shaft assembly gear.

**7.** Hub gear worn.

**8.** Wheel bearings worn or out of adjustment.

**Problem: Leakage of lubricant.**

**Probable cause:**

**1.** Loss through hub seals.

**a.** Lubricant above specification level.

**b.** Wrong kind of lubricant.

**c.** Restriction of axle housing breather.

**d.** Hub oil seal installed wrong or has damage.

**2.** Loss at bevel input pinion shaft.

**a.** Lubricant above specification level.

**b.** Wrong kind of lubricant.

**c.** Restriction of axle housing breather.

**d.** Pinion oil seal worn or not installed correctly.

**Problem: Drive wheels do not turn.**

**Probable cause:**

**1.** Broken axle shaft.

**a.** Loose wheel bearings.

**b.** Axle shaft too short.

**2.** Side gear or differential pinion broken.

**3.** Differential pinion shaft or spider broken.

## Check List from Pressure Test

**Problem: Low pressure to FORWARD and REVERSE clutches.**

**Probable cause**:

**1.** Inching valve linkage adjustment is not correct.

**2.** Inching valve reducing spool stuck open.

**3.** Clutch piston seals cause leakages.

**4.** Main relief valve setting too low caused by a defective relief valve spring.

**5.** Low oil pressure. See Probable Cause for Low Oil Pressure.

**6.** External oil lines are not connected correctly.

**7.** Modulating valve assembly stuck.

**Problem: Clutch pressure and pump pressure are high**.

**Probable cause:**

**1.** Main relief valve is stuck.

**2.** A restriction in the hydraulic circuit.

**3.** Main relief valve not adjusted properly.

**Problem: Pressure to one clutch is low.**

**Probable cause:**

**1.** Clutch piston seal alignment is not correct, oil leaks through.

**2.** Seal rings on shaft or clutch piston seals are broken or worn.

**3.** Modulating valve assembly stuck.

Problem: Low pump pressure.

**Probable cause:**

**1.** Low oil level.

**2.** Main relief valve movement is restricted.

**3.** Transmission oil pump is worn.

**4.** Inner oil leakage.

**5.** Main relief valve not adjusted properly.

**Problem: Low lubrication pressure or no lubrication pressure.**

**Probable cause:**

**1.** Low oil pressure or no oil pressure caused by:

- **a.** Failure of the oil pump or a defect in the oil pump.
- **b.** Restriction in the oil flow circuit such as a dirty oil screen.
- **c.** Inching valve reducing spool stuck open.
- **d.** Leakage inside of transmission caused by component defects.

**2.** Oil cooler has restriction to oil flow.

**Problem: High lubrication pressure.**

**Probable cause:**

**1.** Restricted external oil lines or internal passages.

**2.** External oil lines are not connected correctly.

**Problem: High converter charge pressure.**

**Probable cause:**

**1.** A plugged converter bypass orifice.

**2.** A restriction inside the converter assembly.

**3.** A plugged oil flow passage.

Problem: Low converter charge pressure.

**Probable cause**:

**1.** Converter relief valve stuck open.

**2.** Main relief valve movement is restricted.

**Problem: Low converter outlet pressure or cooler inlet pressure.**

**Probable cause:**

**1.** Low oil pressure.

**2.** Cooler relief valve stuck open.

Problem: High converter outlet pressure or cooler inlet pressure.

**Probable cause:**

**1.** Restriction in oil cooler lines or a plugged oil cooler.

Problem: Low stall speed.

**Probable cause:**

**1.** Engine performance is not correct.

**2.** The one-way clutch of the torque converter does not hold.

Problem: High stall speed in both directions.

**Probable cause:**

**1.** Low oil level.

**2.** Air in the oil.

**3.** Clutches slip (clutch plates slide in relation to one another).

**4.** Torque converter failure.

**Problem: High stall speed in one direction.**

**Probable cause:**

**1.** There is a leak in the clutch circuit.

**2.** There is a failure in that clutch assembly (clutch slipping).

**Problem: Selector spool problems.**

**1. Transmission stays in neutral, no shift.**

**Probable cause:**

**1.** Spools mechanically stuck

- **a.** Contamination
- **b.** Case or body not flat
- **c.** Bore / spool worn

**2.** Solenoids not working

- **a.** O-rings leaking (cut)
- **b.** O-rings missing
- **c.** Ports not machined properly
- **d.** Contamination in solenoid
- **e.** Electrical problem

**3.** Orifice plugged

- **a.** With debris
- **b.** Bad part

**4.** Modulation valve stuck in "off" position

**5.** Modulation valve not correctly assembled.

**2. Transmission will not shift into or out of 1 gear**

**Probable cause:**

**1.** Spools mechanically stuck (same as above)

**2.** Solenoids not working (same as above)

**3.** Valve not correctly assembled (same as above)

**4.** Holes not drilled into case properly

**5.** Excessive leakage internally in body

- **a.** Porosity in body
- **b.** Selector bore too large
- **c.** Spool too small
- **d.** Slug/spool fit not right.

**Problem: Modulation spool problems.**

**1. Slow or no modulation of both clutches**

**(If only 1 clutch does not modulate correctly then the problem is either with the selector spool or it is a problem in the transmission).**

**Probable cause:**

**1.** orifice plugged with debris

**2.** Modulation valve stuck

**3.** Modulation valve not correctly assembled.

**4.** Load piston problem

- **a.** Stuck in bore
- **b.** Excessive valve / bore clearance
- **c.** Missing springs

**5.** Porosity in body in the area of load piston cavity

**2. Modulation time is too quick**

**Probable cause:**

**1.** The upstream orifice (in the oil supply) is not installed. (The orifice is located in the valve block)

**2.** The load piston is only moving a small amount before it sticks. Check the spool to see if it freely fits in the bore. This check must be made while the aluminum body is still bolted down to the transmission.

**3.** The plastic orifice is not installed or the hole in the plastic housing is too large.

**4.** The modulating valve is stuck in an open position. Check to see if the valve moves freely while the aluminum body is still bolted down.

**5.** The springs are not installed or the pin has jammed the load piston

# Transmission Pressure Test

| Tools Needed | |
|---|---|
| Pressure Gauge Group | 1 |

**⚠ WARNING**

**To prevent personal injury, when the transmission is tested, move the truck to a clear area, that is level. Keep all other personnel away from the lift truck. Use lifting equipment or a save method to lift the front of the lift truck until the drive wheels are off the floor. Put wood blocks or jack stands of the correct capacity under it to hold it in this position while pressure tests are performed.**

---

When the transmission tests are made, the transmission oil must be at the correct level. The pressure given in the chart are taken with the transmission oil temperature at 49 to 71°C (120 to 160°F). If the oil temperatue is lower than 49°C (120°F) the oil pressure will be higher than that shown. If the oil temperature is higher than 71°C (160°F), the pressure will be lower than that shown.

Raise the front of the lift truck off the floor. Put wood blocks or jack stands of the correct capacity under it to hold it in this position while pressure tests are performed.

**⚠ WARNING**

**Before any pressure tap plugs or connections are removed, the engine must be stopped with the transmission controls in NEUTRAL. This will release hydraulic pressure in the transmission.**

---

For more identification of transmission problems, the pressures that follow can be checked.

**a.** Pump pressure in neutral.

**b.** Forward clutch pressure in forward.

**c.** Reverse clutch pressure in reverse.

**d.** Converter charge pressure in neutral.

**e.** Converter outlet or cooler inlet pressure in neutral.

**f.** Lubrication pressure in neutral.

Most problems in the hydraulic circuit can normally be found when the pump pressure is checked. If more information is necessary, gauges can be installed at each pressure tap location. Locations of the pressure taps and procedures for testing are given as follows. If any of the pressures are not correct, refer to Troubleshooting For Problems and Probable Causes.

**1.** Be sure the transmission control adjustments are correct before tests are made.
See Inching Pedal Adjustment in Testing and Adjusting.

**2.** Install a tachometer to the engine to show engine speed during the test.

**3.** Put a thermistor probe in place of the dipstick in the transmission oil reservoir.

**4.** Remove each of the following pressure tap plugs in the order shown and install the 0 to 2050 kPa (0 to 300 psi) pressure gauge. After the pressure check is done, remove the gauge and install the plug again.

**5.** Check pump pressure with the transmission in neutral at pressure tap (6) on the valve body first. If it is not correct, then check pump pressure at pressure tap (1) on the bearing plate.

**a.** If the pressure is low at pressure tap (6), but correct at pressure tap (1), there could be an oil line restriction or a defective inching valve.

**NOTE:** Pump pressure should be checked at pressure tap (6) first because pressure tap (6) is easier to get to than pump pressure tap (1) on the bearing plate. If pump pressure is correct at pressure tap (6), it will be correct at pressure tap (1) also.

**b.** If the pressure is low at both locations, see Problem: Low pump pressure in Troubleshooting.

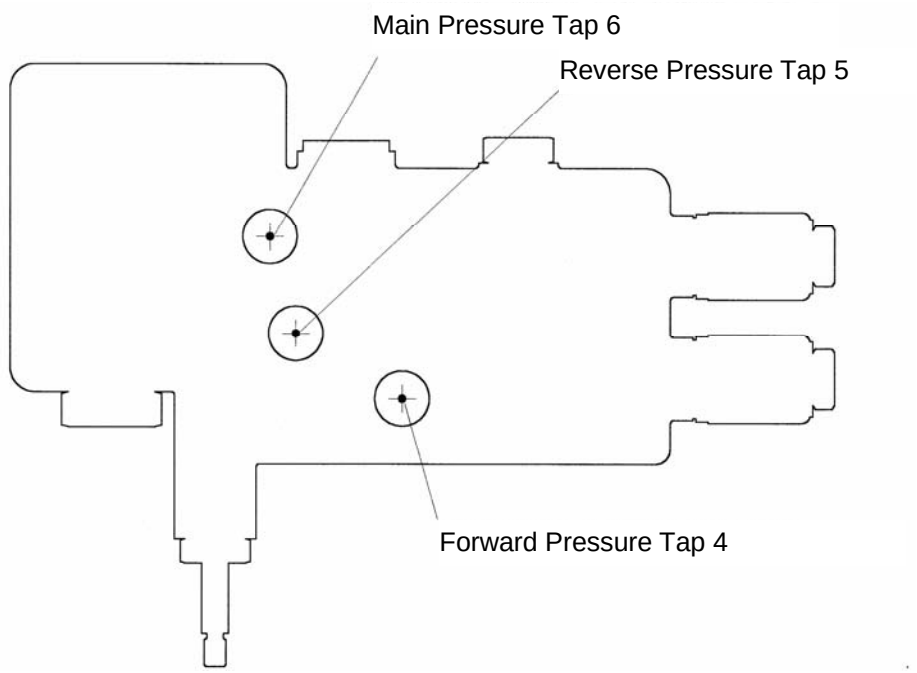
**NOTE:** Pump pressure is adjusted by adding or removing shims in the D700296 Plug. The plug is located in the main relief valve on the valve body.

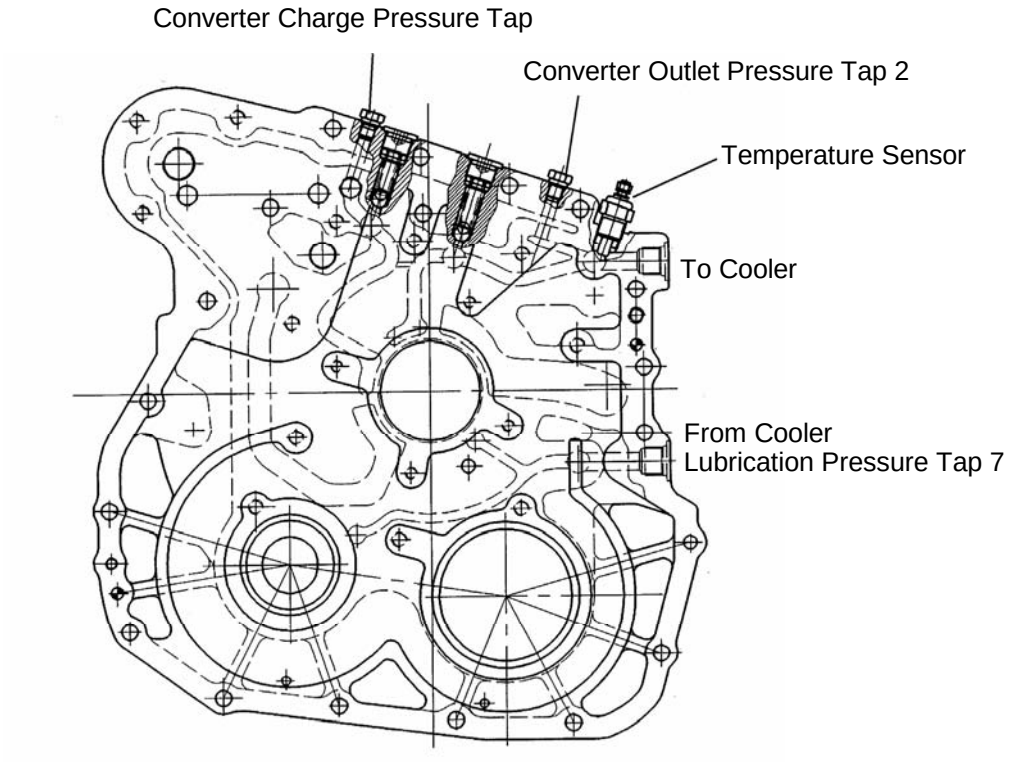
**6.** Check clutch pressure as follows:

**a.** Check forward clutch pressure at pressure tap (4) with the transmission in forward. If the pressure is not correct, see Problem: Low forward clutch pressure in Troubleshooting.

**b.** Check reverse clutch pressure at pressure tap (5) with the transmission in reverse. If the pressure is not correct, see Problem: Low reverse clutch pressure in Troubleshooting.

**Pressure Tap Locations – Transmission Control Group**



**7.** Check lubrication pressure at pressure tap (7) with the transmission in neutral.

**a.** If lubrication pressure is low, see Problem: Low lubrication pressure in Troubleshooting.

**b.** If lubrication pressure is high, see Problem: High lubrication pressure in Troubleshooting.

**8.** Check converter charge (inlet) pressure at pressure tap (3) with the transmission in neutral.

**a.** If converter charge pressure is low, see Problem: Low converter charge pressure in Troubleshooting.

**b.** If converter charge pressure is high, see Problem: High converter charge pressure in Troubleshooting.

**9.** Check converter outlet or cooler inlet pressure at pressure tap (2) with the transmission in neutral.

**a.** If the pressure is low, see Problem: Low converter outlet or cooler inlet pressure in Troubleshooting.

**b.** If the pressure is high, see Problem: High converter outlet or cooler inlet pressure in Troubleshooting.

**NOTE:** Do not activate the inching pedal when pressure checks are made. Check for the pressures as shown in Transmission Pressure Chart in the order that follows:

| Transmission Pressure Chart | | |
|---|---|---|
| | **Low idle** | **2000 rpm** |
| **Shift position - Neutral** | | |
| Main Line | 830 to 1,030, kPa (120 to 150psi) | 895 to 1,100,kPa (130 to 160psi) |
| Clutch | 0 kPa (0 psi) | 0 kPa (0 psi) |
| Lubrication | 14 to 70 kPa (2 to 10 psi) | 240 to 345 kPa (35 to 50 psi) |
| Converter Chage | 70 to 140 kPa (10 to 20 psi) | 590 to 795 kPa (85 to 115 psi) |
| Converter Outlet or Cooler Inlet | 25 to 55 kPa (4 to 8 psi) | 250 to 400 kPa (36 to 58 psi) |
| **Shift position – Forward or Reverse** | | |
| Main Line | - | - |
| Clutch | 725 to 860 kPa (105 to 125 psi) | 725 to 965 kPa (105 to 140 psi) |
| Lubrication | - | - |
| Converter Chage | - | - |
| Converter Outlet or Cooler Inlet | - - | - - |

## Converter Stall Test

**NOTE:** Make sure that the transmission oil is at the correct temperature for operation before tests are made.

The converter stall test is a test to check engine power. It can also be used to locate a problem in the transmission or torque converter when the condition of the engine is known. An engine, which does not have correct performance, will give an indication of a stall speed that is not correct. If the engine performance is correct and the stall speed is not correct, the problem in the converter or transmission can be found with this test.

**NOTE:** To check the engine performance, see the respective engine module. This test checks the maximum RPM that the engine, at full throttle, can turn the converter with the turbine held stationary. To hold the converter turbine, engage the brakes with the transmission in FORWARD or REVERSE.

The drive wheels must not turn during the stall test. Put a heavy load on the forks. Also put the truck in position against a solid object that will not move (such as a loading dock). When the tests are made, the wheel brakes must be engaged with the left foot. The accelerator pedal can be operated with the right foot.

**⚠ WARNING**

**Make tests in a clear level area only. There must be one operator. Keep all other personnel away from the lift truck. Check the operation of the brakes before the tests are made.**

Check the high idle setting before the stall test is made. Set the high idle to the specification, as given in the respective engine module.

**NOTE:** Make sure that the transmission oil is at the correct temperature for operation before tests are made.

**1.** Connect a tachometer to the engine. Start the engine. Engage the wheel brakes with the left foot.

**2.** Put the transmission control lever in FORWARD and push the accelerator pedal down completely with the right foot. Read the RPM on the tachometer, then release the accelerator pedal.

**NOTICE**

To make sure that the transmission oil does not get hot, do not hold the transmission in a stall condition for more than ten seconds. After the transmission is stalled, put the controls in NEUTRAL and run the engine at 1200 to 1500 RPM to cool the oil.

**3.** Repeat the procedure above for the REVERSE direction.

**4.** The stall speeds for the different trucks are listed in the charts that follow:

| LIFT TRUCK STALL SPEED | | | Engine Max.RPM |
|---|---|---|---|
| Engine | RPM±100 Without Power Brakes Applied | RPM±100 With Power Brakes Applied | - |
| B3.3 | 1,780 | 1,680 | 2,200 |
| 4TNV98 | 1,840 | 1,740 | 2,350 |
| 4TNE98 | 1,720 | 1,620 | 2,540 |
| HMC G420F(E) LP | 1,860 | 1,760 | 2,500 |
| HMC G420F(E) GAS | 1,860 | 1,760 | 2,500 |
| HMC G420F(E) Dual | 1,860 | 1,760 | 2,500 |
| GM G424F(E) LP | 2,030 | 1,930 | 2,550 |
| GM G424F(E) GAS | 2,030 | 1,930 | 2,550 |
| GM G424F(E) Dual | 2,030 | 1,930 | 2,550 |

Stall speeds that are low are an indication that the engine performance is not correct or the one-way cutch of the torque converter does not hold in reverse direction. If the one-way clutch has a defect, the stall speed will probably be more than 800 rpm low.

The stall speed must be the same in FORWARD and REVERSE. If the stall speed is high in FORWARD and REVERSE, check the following:

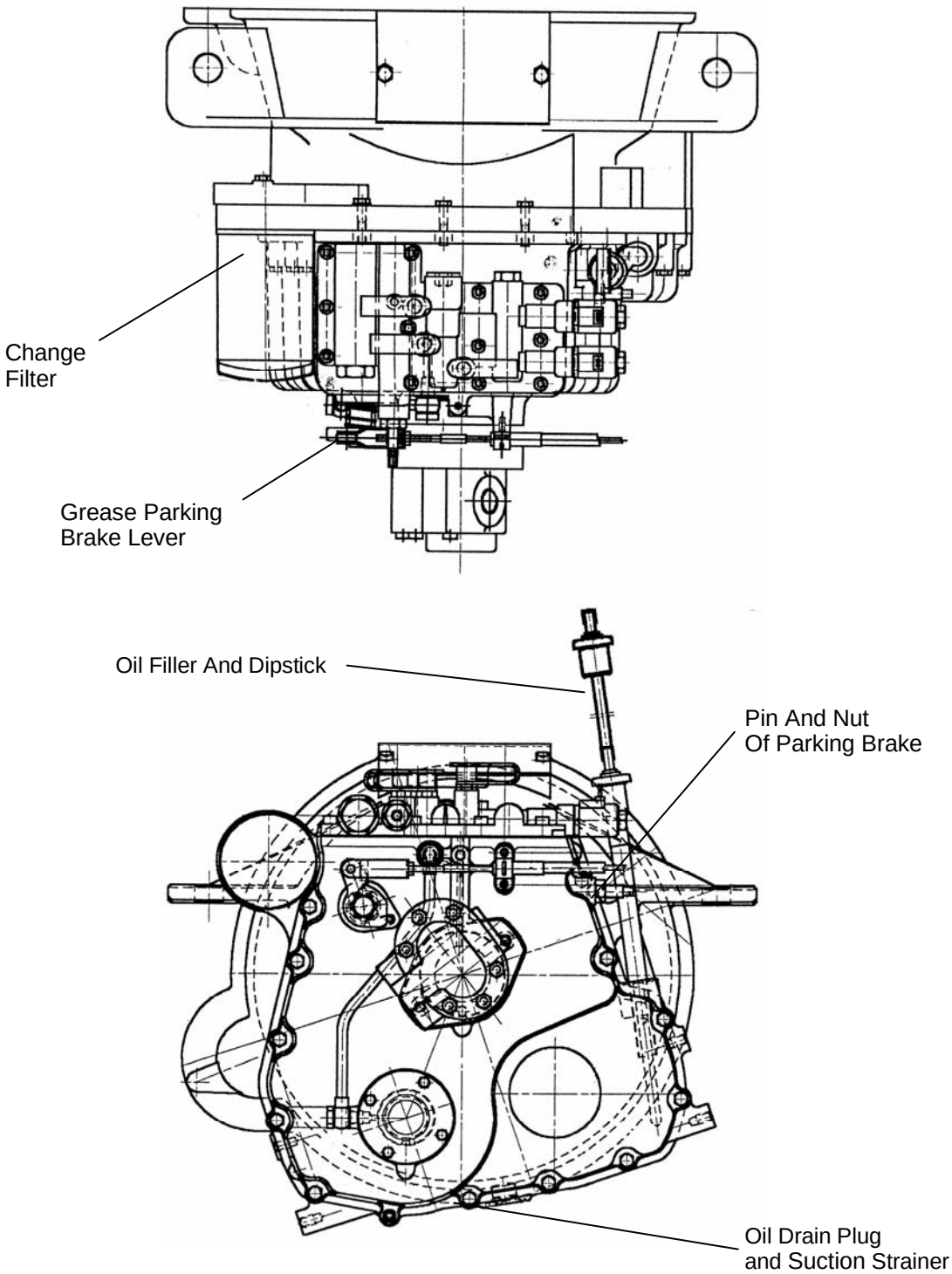
**a.** Check for air in the oil.

**b.** Check the torque converter and the clutch pressures according to transmission Pressure Tests in Testing and Adjusting.

**c.** If clutch pressure is correct, make an inspection of the clutch assembly for that direction for possible damage to clutch components.

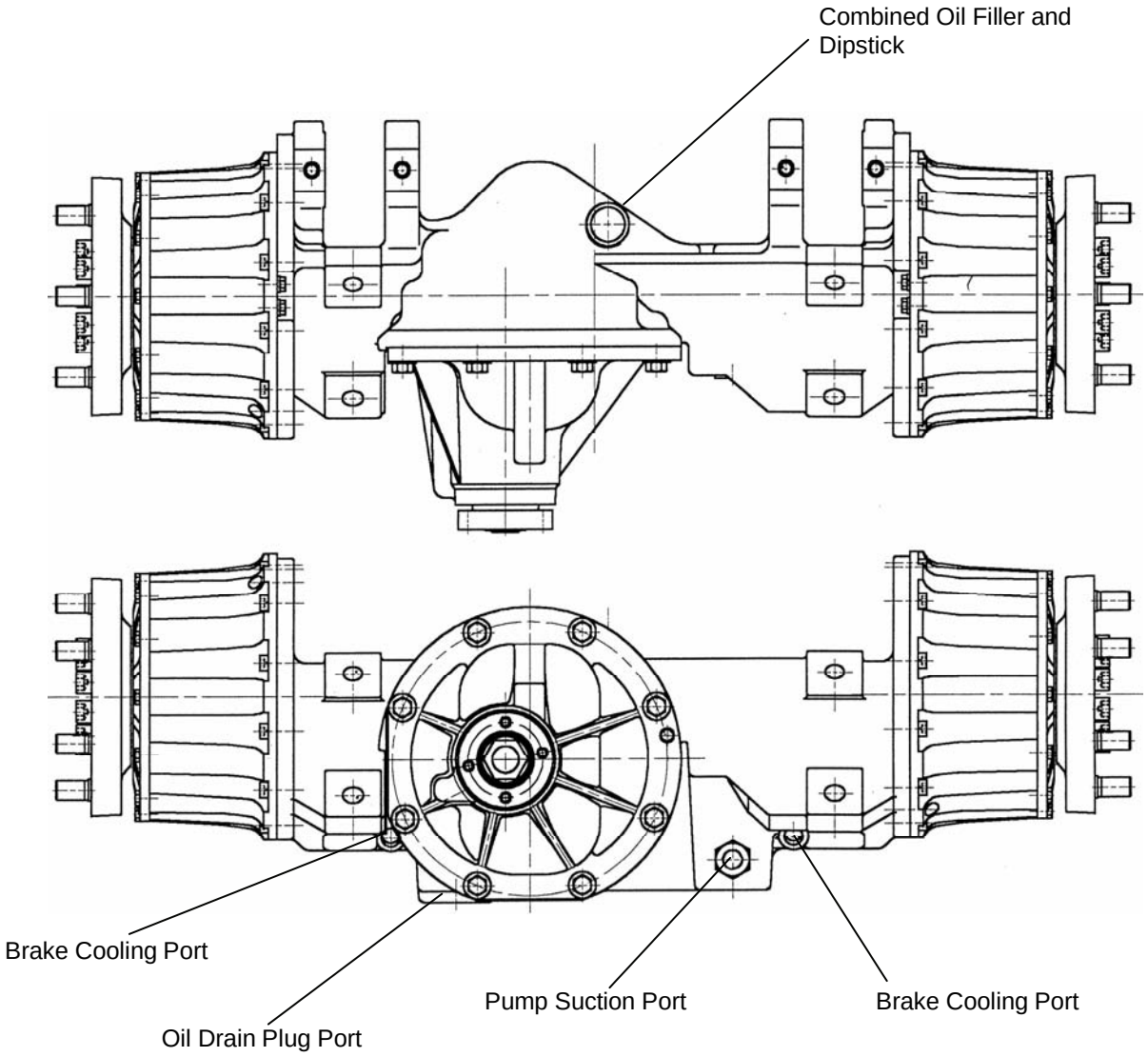
# Maintenance

## Transmission




**ATTENTION:** When changing oil, replace filter and clean suction strainer.

## Drive Axle




**ATTENTION:** Clean suction strainer when replacing oil.

## Electric Control System Tests

| Tools Needed | |
|---|---|
| Digital Multimeter | **1** |

**NOTE :** Refer to Schematic.

Checks on the transmission directional control electrical circuit can be done with a Digital Multimeter. All voltage checks are made at the wiring harness connectors with the ignition switch ON, DO NOT start the engine. All continuity checks are done with the ignition switch OFF.

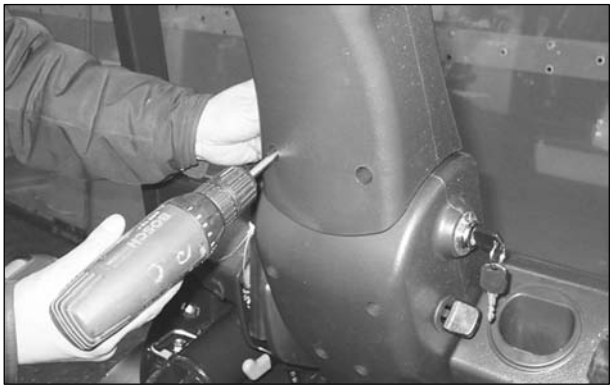
A beginning check of the direction control system should be performed before testing the individual components and wiring harness. When the direction solenoids are energized they become magnetized. By holding a metal screwdriver next to the solenoids it can be determined whether they are energized or not.

Turn the ignition switch ON, DO NOT start the engine. Release the parking brake. Place the direction control switch in forward and check the forward solenoid for magnetism. Do the same for the reverse direction.

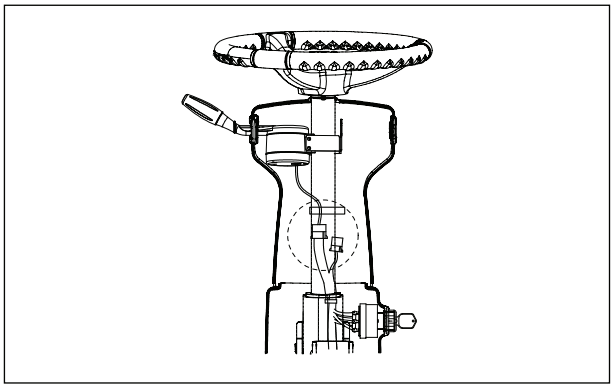
- If the solenoids didn't energize begin testing the control system with step 1.
- If the solenoids did energize, go to step 10.

## Directional Control Switch Check

**1.** Put the directional control lever in neutral. Remove the cover from the front side of front cockpit unit.



**2.** Disconnect harness connector from directional control switch connector.



Directional Control Switch Connector

**3.** Engage the parking brake and turn the ignition switch ON, DO NOT start the engine. Put the multimeter on the 20 volt range.

**4.** Put the (-) probe on a good ground. Put the (+) probe on socket 1 of harness connector.

**a.** If the indication is battery volts, do Step 5.

**b.** If the indications 0 volts, check the Forward/Reverse fuse (No.3) located in the fuse box and check the connecting wires for continuity.

**5.** Turn the ignition switch OFF and put the multimeter on the 200 ohm range.

**6.** Check continuity between pins 4 and 7 of directional switch connector with the switch in neutral. Forward and then reverse the positions. There should be continuity in neutral and no continuity in forward and reverse.

**a.** If the above checks are correct, do Step 7.

**b.** If any of the above checks are not correct, replace the directional control switch.

**7.** Check continuity between pins 1 and 2 of directional switch connector in forward and then neutral position. There should be continuity in forward and no continuity in neutral. While the continuity is checked in forward position, move the lever back and forth (but stay in forward position) to see if the resistance goes up or down. The resistance should be constant.

**a.** If the above checks are correct, do step 8.

**b.** If the above checks are not correct, replace the directional control switch.

**8.** Check continuity between pins 1 and 3 of directional switch connector (1) in reverse and then neutral positions. There should be continuity in reverse and no continuity in neutral. While the continuity is checked in reverse position, move the lever back and forth (but stay in reverse position) to see if the resistance goes up or down. The resistance should be constant.

**a.** If the above checks are correct, do Step 9.

**b.** If any of the above checks are not correct, replace the directional control switch.

**Transmission Control Harness Check**

**9.** Disconnect the connector of Engine harness from the connector of transmission harness. Check the continuity of engine harness from one end to the other. Repair or replace the wiring harness if there is no continuity.

**Transmission Solenoids Visual Check**

**10.** A visual check can be done to see if the solenoid plungers are moving.
Remove the modulating valve assemblies from the transmission

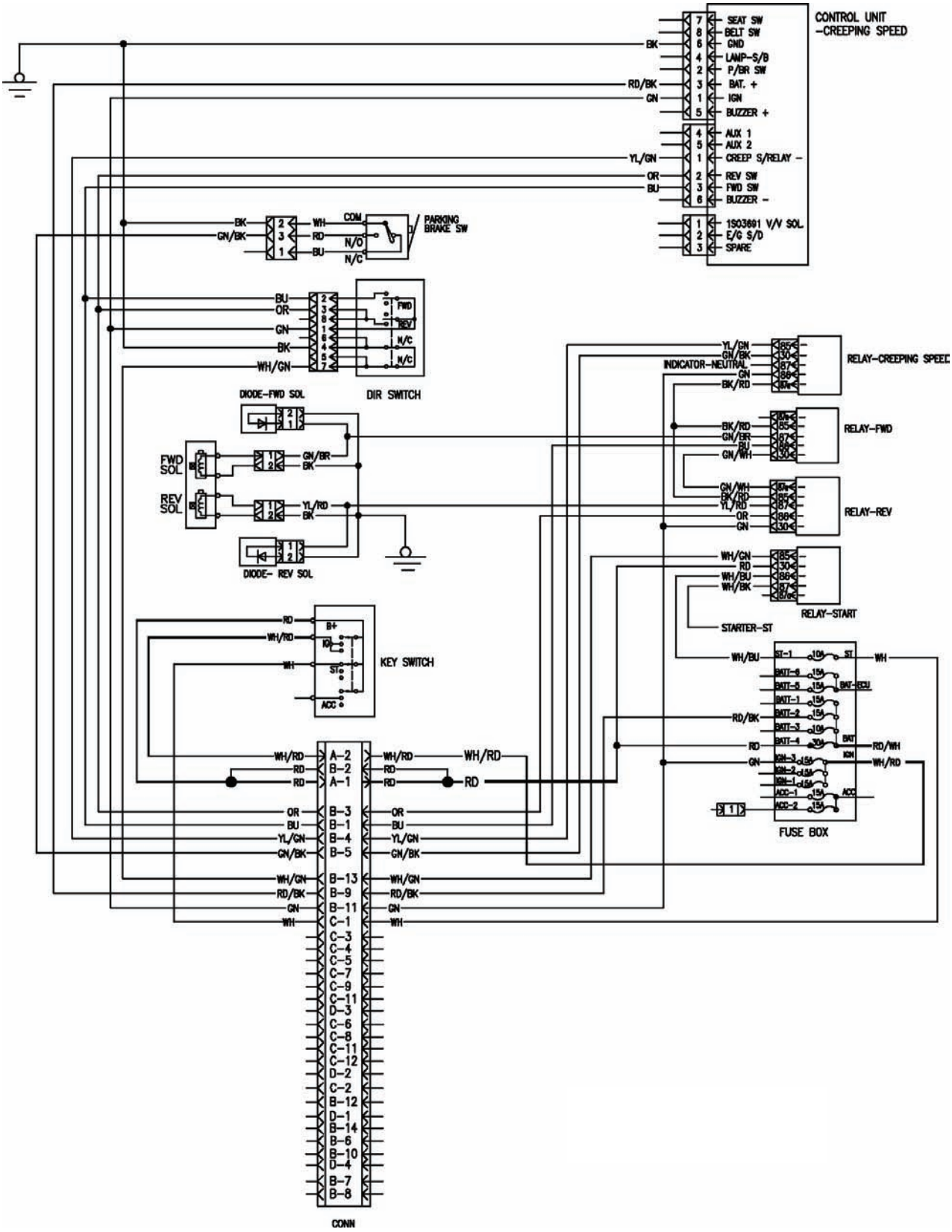
**11.** Turn the ignition switch ON, DO NOT start the engine. Release the parking brake.

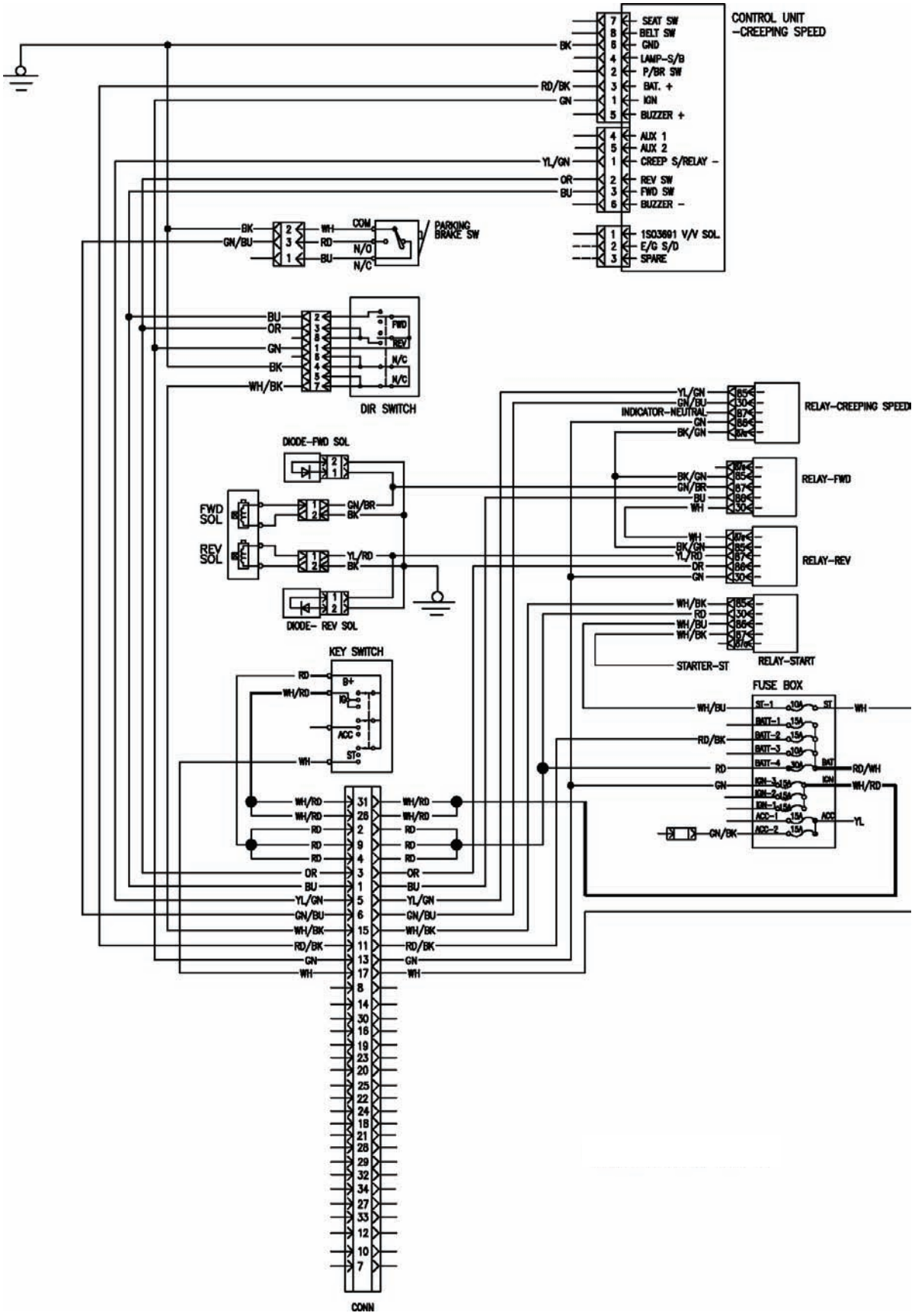
**12.** Put the directional control switch in neutral.
Both solenoid plungers should be flush with the solenoid.

**13.** Put the directional control switch in forward and then reverse.
The plunger of the solenoid that is activated should move in approximately 3.18mm(.125 in).

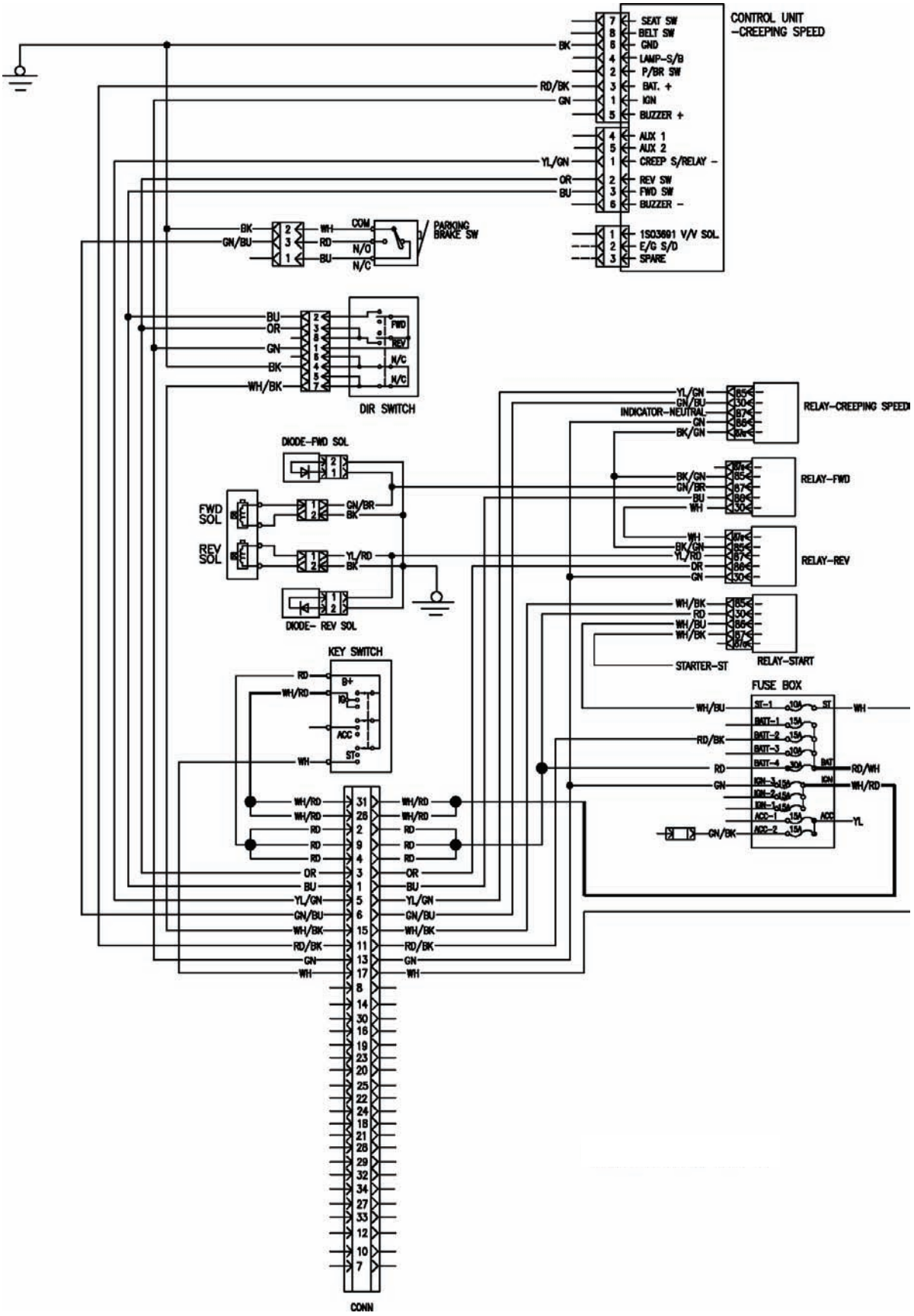
**14.** If the solenoid plungers do not move as explained in Steps 12 and 13, replace the defective solenoid.

**15.** If the solenoid plungers are good, the modulating valves could be stuck or there is mechanical failure in the transmission.

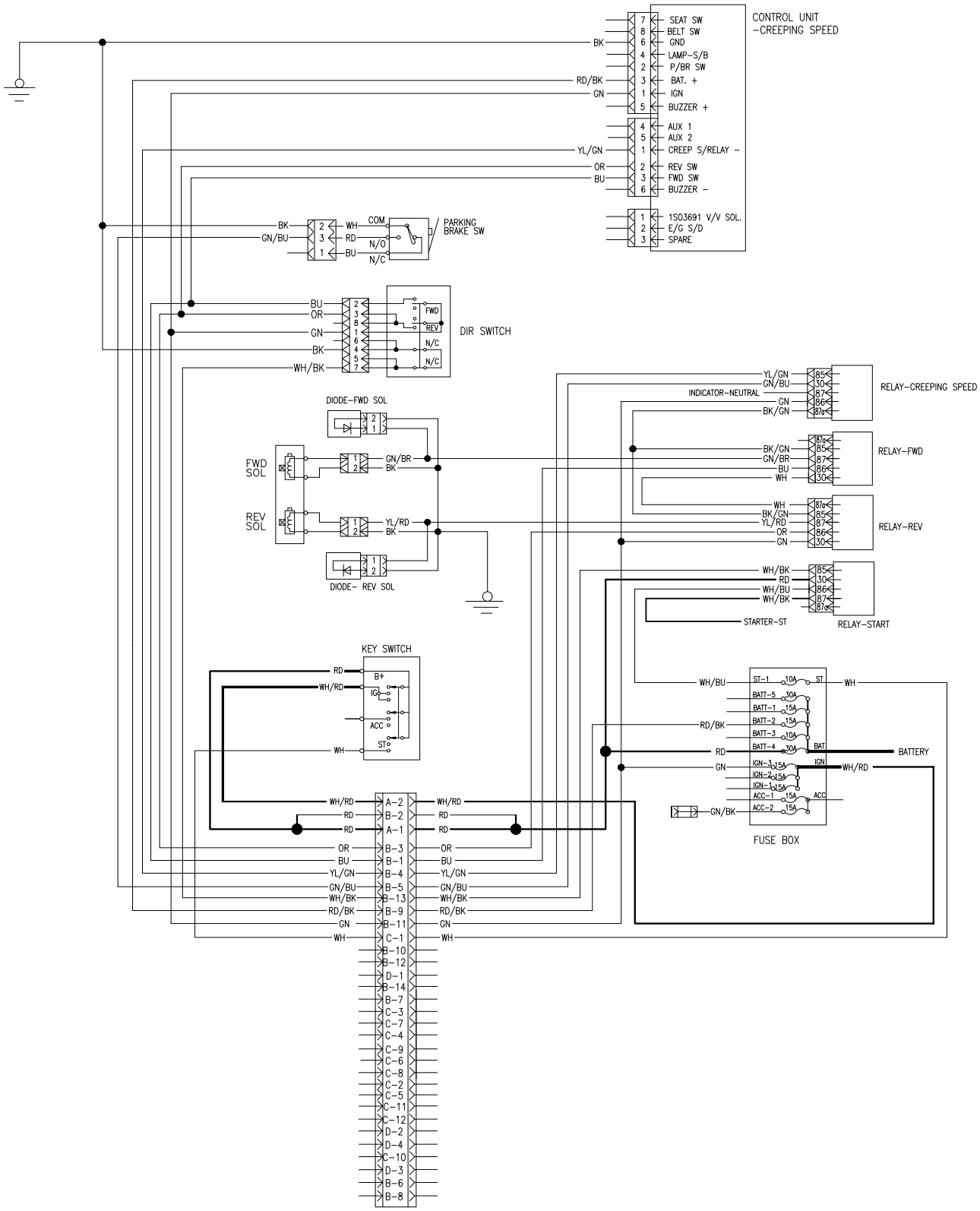

CONTROL UNIT
-CREEPING SPEED
SEAT SW
BELT SW
GND
LAMP-S/B
P/BR SW
BAT. +
IGN
BUZZER +
AUX 1
AUX 2
CREEP S/RELAY -
REV SW
FWD SW
BUZZER -
1S03691 V/V SOL
E/G S/D
SPARE
PARKING BRAKE SW
DIR SWITCH
DIODE-FWD SOL
DIODE- REV SOL
FWD SOL
REV SOL
KEY SWITCH
RELAY-CREEPING SPEED
RELAY-FWD
RELAY-REV
RELAY-START
STARTER-ST
FUSE BOX
CONN


CONTROL UNIT
-CREEPING SPEED
SEAT SW
BELT SW
GND
LAMP-S/B
P/BR SW
BAT. +
IGN
BUZZER +
AUX 1
AUX 2
CREEP S/RELAY -
REV SW
FWD SW
BUZZER -
1SO3691 V/V SOL.
E/G S/D
SPARE
PARKING BRAKE SW
DIR SWITCH
DIODE-FWD SOL
DIODE- REV SOL
FWD SOL
REV SOL
RELAY-CREEPING SPEED
INDICATOR-NEUTRAL
RELAY-FWD
RELAY-REV
RELAY-START
STARTER-ST
KEY SWITCH
FUSE BOX
CONN

**Transmission Directional Control Schematic for D20/33S-5, D35C-5 (Yanmar Engine 4TNV98)**



## Transmission Directional Control Schematic for D20/33S-5, D35C-5 (Yanmar Engine 4TNE98)



# Inching Pedal Adjustment

To check the inching valve adjustment and operation, do the procedure that follows :

**⚠ WARNING**

**When this procedure is used, the lift truck must be in an area clear of obstructions. There must be one operator with all other personnel away from the lift truck. Check the operation of the brakes before the test is made.**

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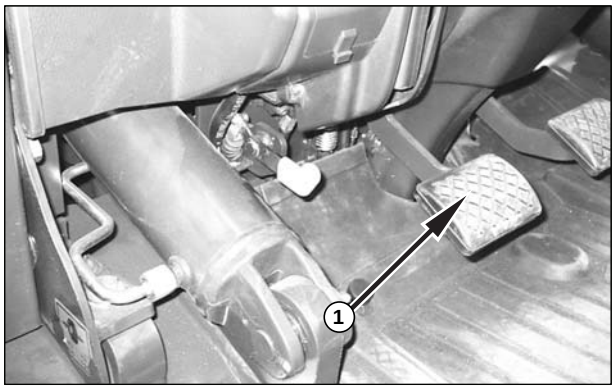
**1.** With the engine at idle speed, put the transmission in FORWARD.




Inching Operation Test
(1) Inching pedal.

**2.** Slowly push down on inching pedal (1) until the movement of the brake pedal causes the brake discs to make contact (small drag) with the brake plates.

**3.** Increase the engine speed to high idle. The truck must not move.

If the operation of the inching valve is not correct, do the procedure that follows.

**1.** Adjust and bleed the wheel brakes as shown in the Vehicle Systems module.

**⚠ WARNING**

**To prevent personal injury, when the inching pedal is adjusted, move the truck to a clear area that is level. Keep all other personnel away from the lift truck. Use lifting equipment or a safe method to lift the front of the lift truck until the drive wheels are off the floor. Put wood blocks or jack stands of the correct capacity under it to hold it in this position while the inching pedal is adjusted.**

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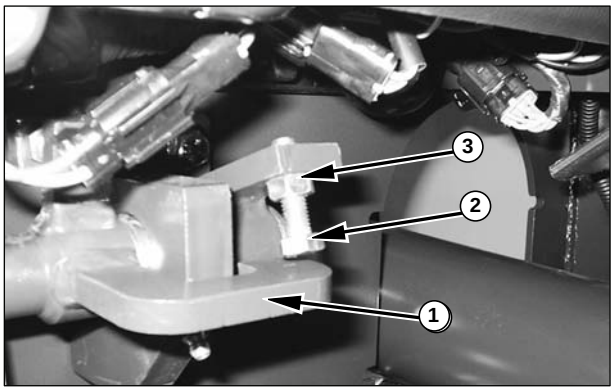
**2.** Raise the front of the lift truck off the floor. Put wood blocks or jack stands of the correct capacity under it while the inching pedal is adjusted.




Inching Pedal Adjustment
(1) Lug. (2) Bolt. (3) Nut.

**3.** Start the engine and put the transmission FORWARD.

**4.** With the drive wheels turning, depress inching pedal until the drive wheels stop.

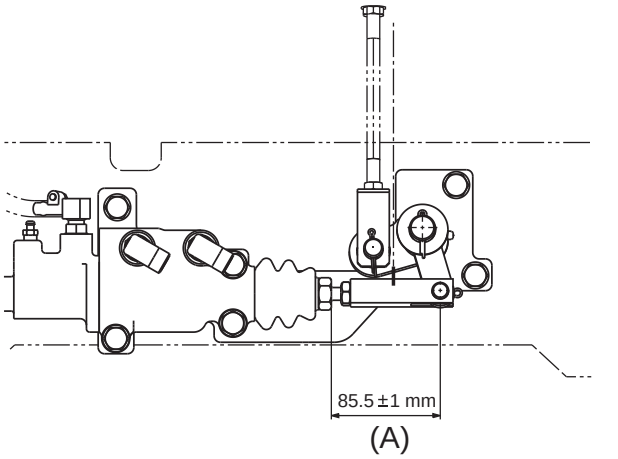
**5.** Now depress the brake pedal until disc contact is felt.

**6.** Loosen nut (3) and adjust bolt (2) to contact lug (1) that rotates the brake control cross shaft. Tighten nut (3).

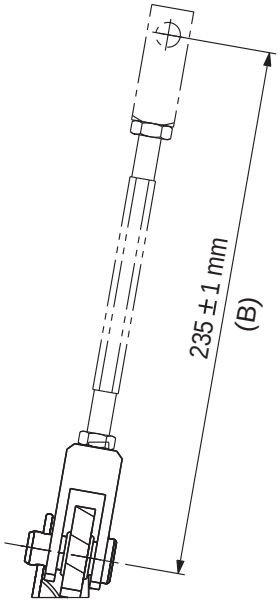
**7.** Check the inching valve operation again.

**a.** If something is wrong, inspect all points again one by one very carefully.

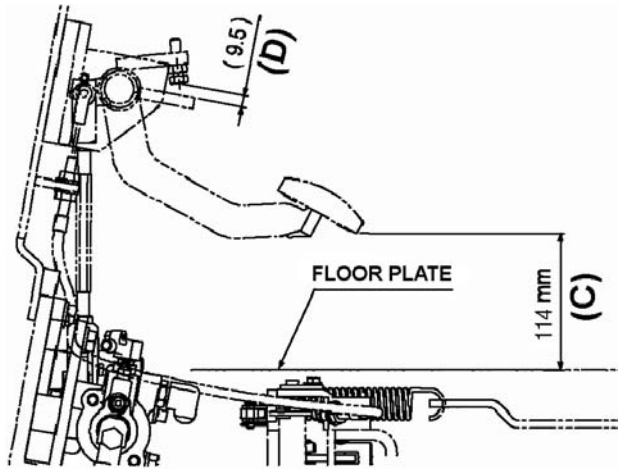
The adjusting procedure is as follows. Be sure that the air bleeding of brake system should be done in advance.




**1.** Adjust the length (A) from the spool to the connection point of yoke. (A) should be 85.5 ± 1mm. Be sure that 1mm of gap between the piston and the rod should exist. In case of no gap, it would result in brake drag or overheating of axle oil. In case of too loose, the performance of service brake become lowered.

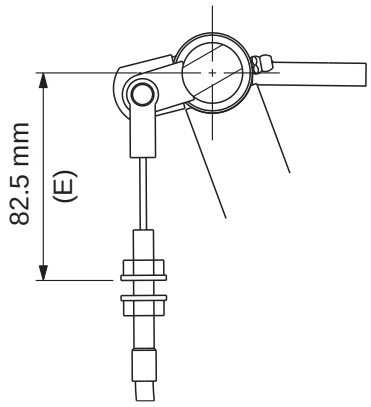



**2.** Adjust the length (B) of rod by fixing the nuts at both ends. (B) should be 235 ± 1mm.




**3.** Adjust the height (C) of inching pedal and brake pedal. (C) should be 110mm at the same level.

**4.** Adjust the gap (D) for engaging brake pedal by inching pedal. (D) should be approx. 9.5mm.




**5.** The distance (E) between the shaft center and its mounting bracket should be 82.5mm.

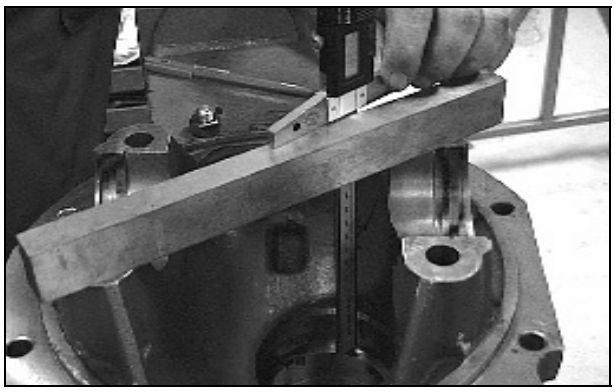
**6.** The stroke of inching spool should be 8 ± 1mm.

**7.** Before doing the truck test, inspect again all relevant dimensions.

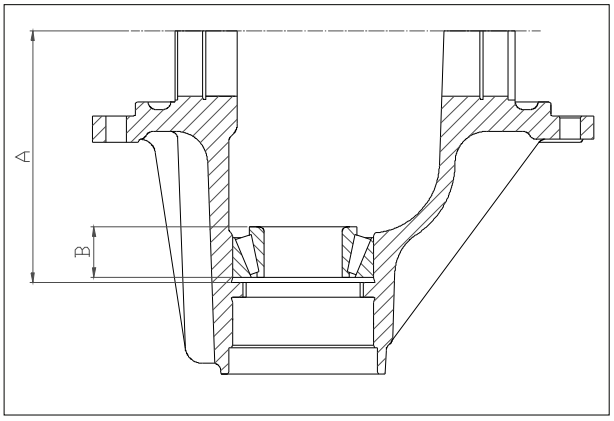
**8.** Inspect the service brake and then, inching operation.

# Adjustments on Drive axle

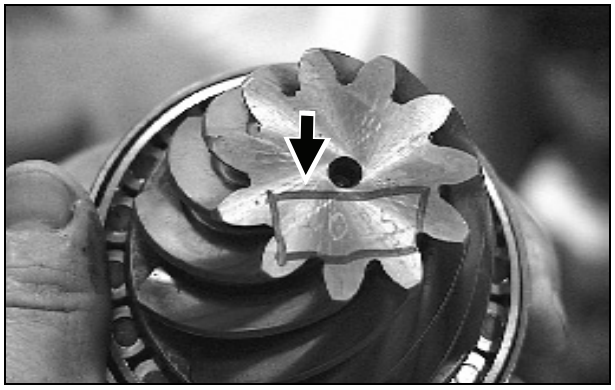
## Axle, Pinion, crown gear



**1.** Measure the depth from center of diff. carrier to the seat of pinion bearing cup. (Dimension A)



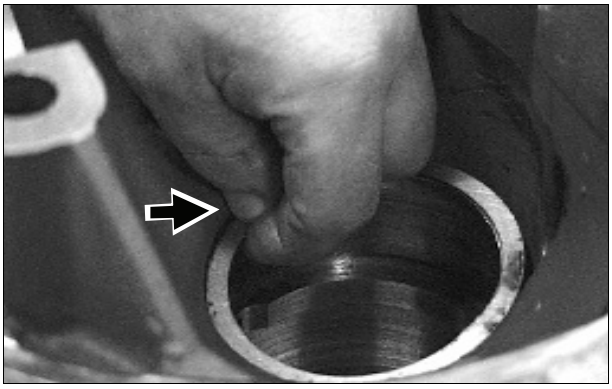

**2.** Measure the width of pinion bearing.(Dimension B)



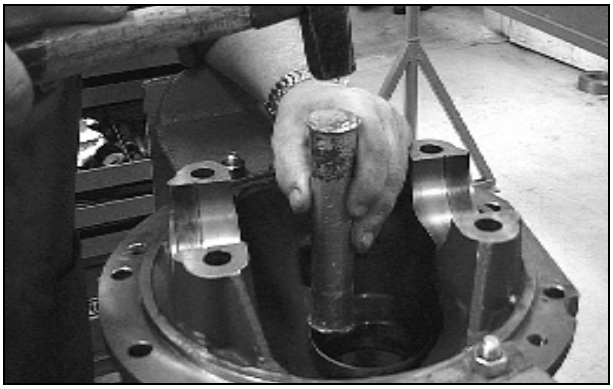
**3.** Check the etched value on the pinion face. (Dimension c)
∗unit : mm

**4.** Calaulate the shimpack thickness according to the following formula.
Shimpack thickness = A-(127+B+C)
Example) if A=160.50, B=32.00, C=+0.05
Then, shimpack thickness
=160.50-(127+32.00+0.05) = 1.45mm

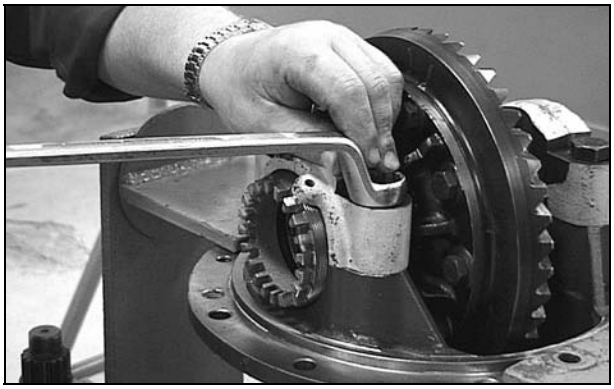
**∗ To minimize the measuring error, measure three places at least and average them.**



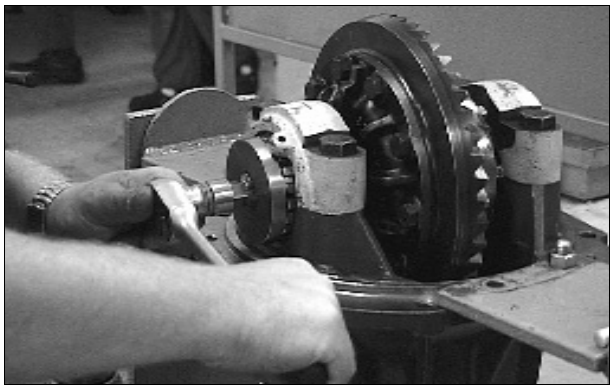
**5.** Shims of calculated thickness laid into bearing seat.



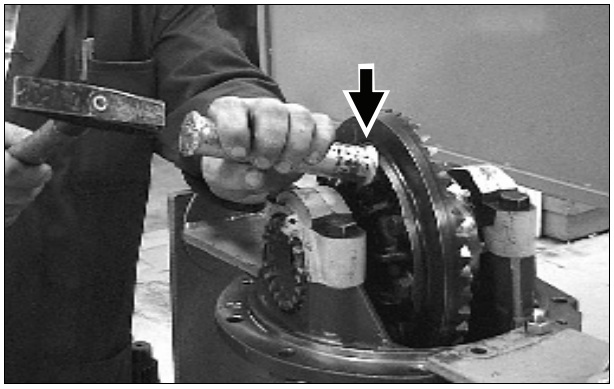
**6.** Install bearing cup.



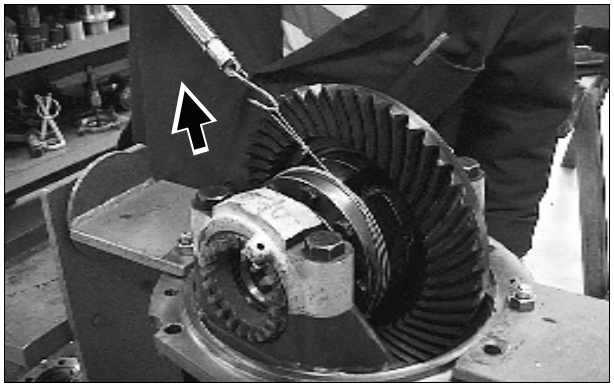
**7.** Install crown gear, differential assy and cap lightly.



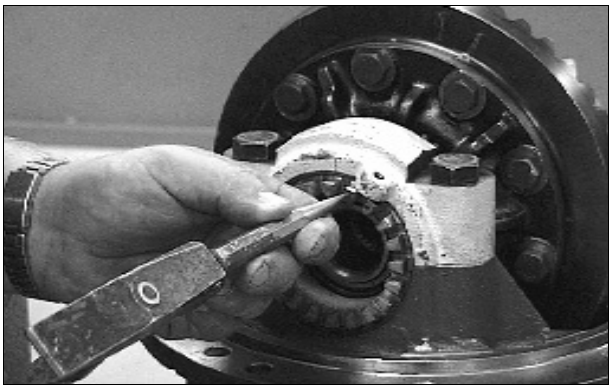
**8.** Install bearing nuts for the correct cap position and lightly torque them to achieve bearing preload.



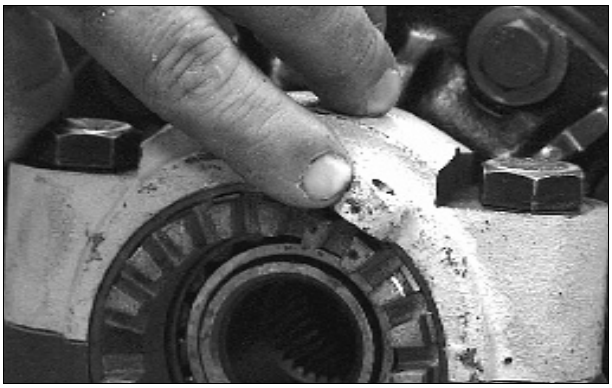
**9.** Tap on differential on both sides to achieve correct bearing cone position, rotate differential (3-5 times).



**10.** Check drag 19.6 N.m (14.5 lb.ft) on rotating differential.



**11.** When drag is correct, mark position of nuts both on nuts and bridge.



**12.** After marking of position remove differential assy.

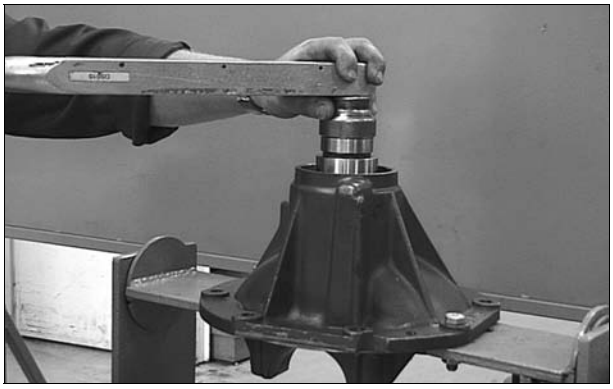
## Installation of Pinion

**1.** Install cup of rear pinion bearing

**2.** Install spacer and shims on pinion (basic thickness 1.5mm (0.059 in)).

**3.** Install bearing cone.

**4.** Tap bearing cone to correct position(Rotate pinion 3-5 times)



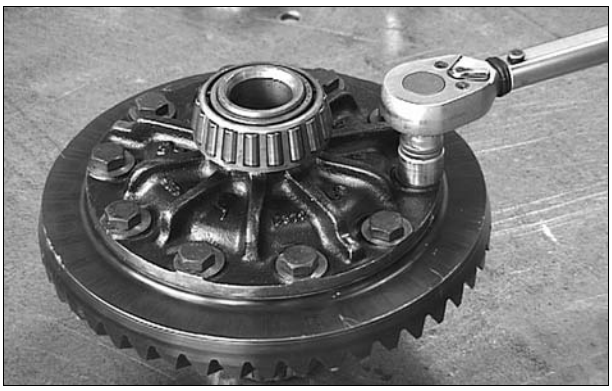
**5.** Assemble yoke and nut and tighten flange nut to 180 ±15 N·m (133±11 lb·ft)

**6.** Measure the rolling torque. The value of rolling torque should be 1.5~2.0 N·m (1.1~1.5 lb·ft)

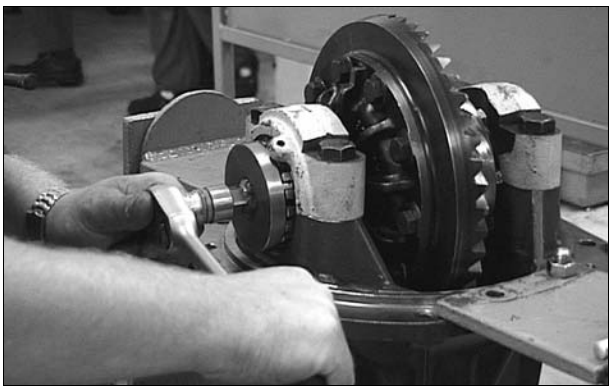
**7.** If the rolling torque exceeds 2 N·m, add one shim and if it is lower than 1.5 N·m, subtract one shim

**8.** When the adjustment is correct, disassemble the nut and the yoke. Assemble the oil seal and yoke again and then tighten the nut to 180 ±15 N·m (133±11 lb·ft)

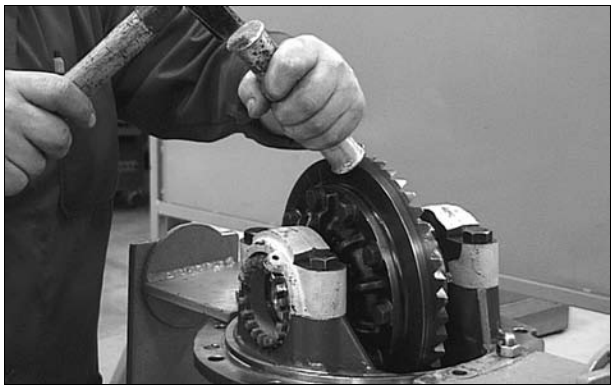
## Adjustment of Crown Wheel



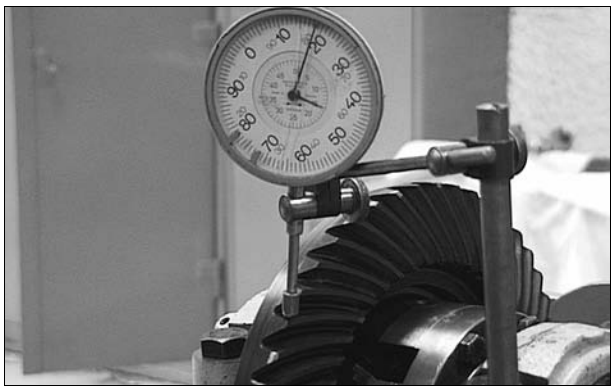
**1.** Torque crown wheel bolts to 80 N·m (59 lb·ft).



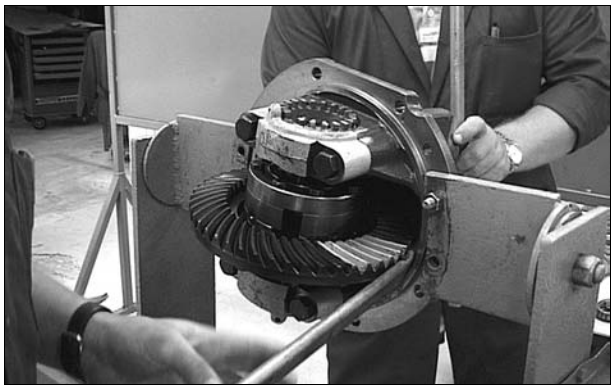
**2.** Install differential assy., to previously mounted position (rotate both nuts simultaneously to maintain bearing preload).



**3.** Tap on both sides of the differential to achieve correct position of bearing cups.

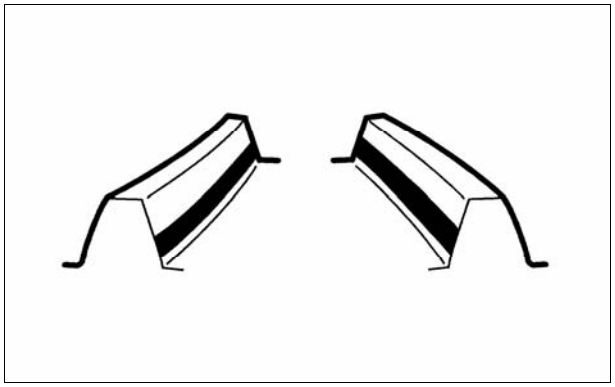


**4.** Check backlash between pinion and crown gear in 3 different positions. Backlash shall be 0.15-0.20 mm (0.006-0.008 in)

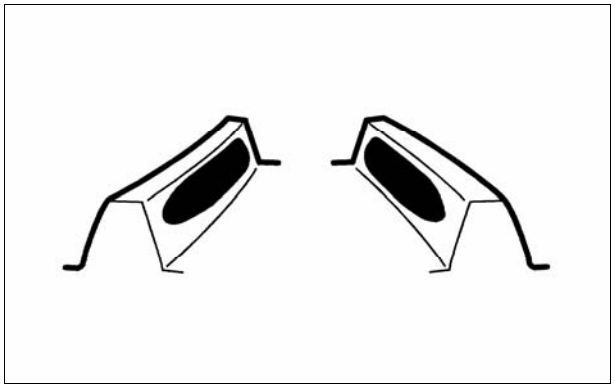


**5.** Check contact face by rotating pinion in both directions, hold back crown wheel.

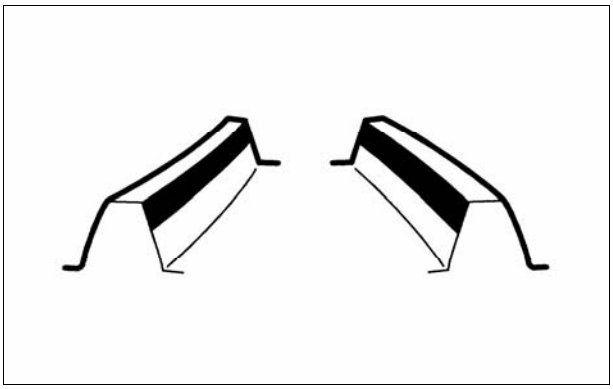
**6.** Check contact area position and correct in accordance with specification if neccessary.



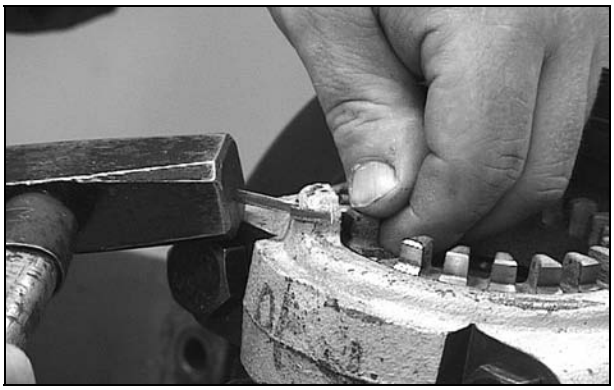
**7.** Position not correct



**8.** Correct position.

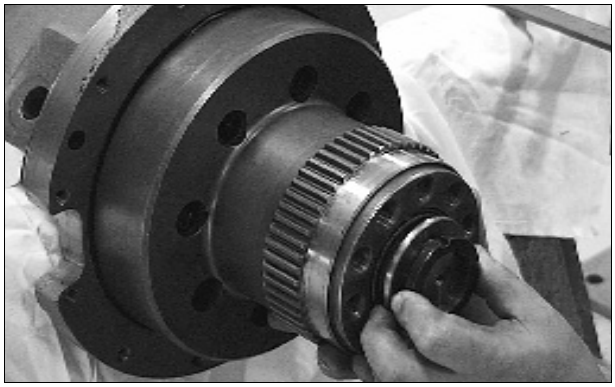


**9.** Position not correct.

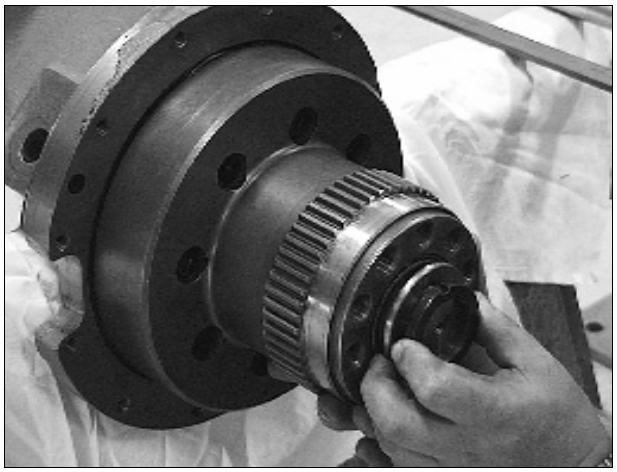


**10.** After correct adjustment of contact area secure differential nut with split pin.

## Adjustment of Wheel Bearings



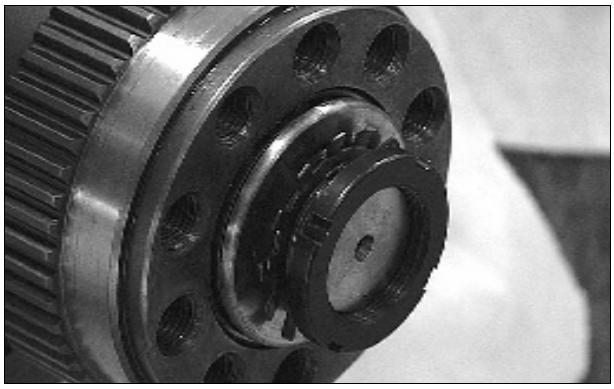
**1.** Assemble outer hub bearing without lockwasher.



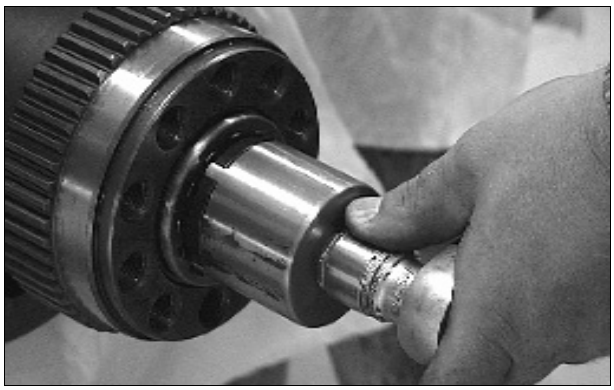
**2.** Tighten wheel nut to 135 ± 14 N·m (100±10 lb·ft).

**3.** Tap on and rotate hub 3-5 times to achieve correct bearing position

**4.** Remove wheel nut for lockwasher installation.



**5.** Install lockwasher and nut.



**6.** Tighten nut to 50 ±5 N·m (37±3 lb·ft).